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ROCKET AND SATELLITE TECHNIQUES FOR MEASUREMENT OF ELECTRON DENSITY AND RELATED IONOSPHERIC PARAMETERS

by

D. A. BURT, G. D. ALLRED and C. D. WESTLUND

Contract No. AF 19(628)-5044
Project No. 7663, 8710, 000D
Task No. 766303, 07, 871000, 000D09
Work Unit No. 76630301, 76630701, 87100001, 000D0001

FINAL REPORT

Period Covered: 1 April 1965 through 31 March 1967

December 1967

Contract Monitor: James C. Ulwick
Upper Atmosphere Physics Laboratory

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Prepared For

Air Force Cambridge Research Laboratories
Office of Aerospace Research
United States Air Force
Bedford, Massachusetts 01730

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University of Utah Salt Lake City, Utah 84112

94

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Submitted by Obed C. Haycock

Obed C. Haycock, Director

ABSTRACT

Normal concentrations of electron density in the earth's ionosphere and changes in these concentrations associated with various disturbances, both natural and manmade, have been investigated by a series of eight rocket and satellite payloads. Instruments for measuring fine scale, long-term deviations and short term, larger scale deviations in electron density and other related parameters have been included in each payload. This report details instrumentation and presents brief results of the experiments developed by Upper Air Research Laboratory, University of Utah for each of the following programs:

Aerobee 150 (3.614)	-	D-region, gyro-interaction
Four Nike-Hydacs	-	Solar eclipse (12 November 1966)
OV2-3 Satellite	-	Electron density at synchronous orbit altitude
OV3-2 Satellite	-	F-region electron density (polar orbit)
Javelin (19.191)	-	F-region irregularities - pulse-phase delay experiment

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List of Related Contracts and Publications

W19-122 ac-15
AF 19(604)-384
AF 19(604)-2227
AF 19(628)-352
AF 19(628)-447
AF 19(628)-4995
F19628-67-C-0275

Linford, R.K., and K.D. Baker, Impedance measurements of unbalanced rocket antennas near the earth's surface, Scientific Report No. 1, Contract No. AF 19(628)-5044, AFCRL-66-658, UU-66-10, University of Utah, Salt Lake City, August 1966.

Seljaas, K.G., and D.A. Burt, Rocket instrumentation for solar eclipse measurements - 12 November 1966, Scientific Report No. 2, Contract No. AF 19(628)-5044, AFCRL-67-0336, UU-67-2, University of Utah, Salt Lake City, April 1967.

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Alley, C.L., D.A. Burt, R.H. Haycock, and G.D. Allred, Rocket instrumentation for the gyro-interaction experiment - Aerobee AE 3.614, Scientific Report No. 4, Contract No. AF 19(628)-5044, AFCRL-67-0584, UU-67-8, University of Utah, Salt Lake City, October 1967.

Baker, K.D., and G.D. Allred, Determination of the electron density in the ionosphere by the pulse delay technique, Final Report, Contract No. AF 19(628)-352, AFCRL-66-55, UU-66-1, University of Utah, Salt Lake City, December 1965.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont.)

LIST OF TABLES

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INTRODUCTION

During the period of this report, a total of eight vehicles including six rockets and two orbiting satellites, having payloads containing experiments designed by Upper Air Research Laboratory, University of Utah, under contract No. AF 19(628)-5044, were launched from geographically diverse sites. The sites included Cassino, Brazil; Eglin Gulf Test Range, Florida; Wallops Island, Virginia; and Vandenberg Air Force Base, California. The operational altitudes for the various experiments ranged from 35,000 km (synchronous orbiting satellite) to the lower D-region of the ionosphere. Although multiple phenomena were investigated, all experiments were designed to obtain measurements of electron density and related parameters in various areas of, and under different situations in, the ionosphere.

Inasmuch as the experiments, vehicles, and locations of firings were of such a diversified nature, a separate section of this report is devoted to information pertinent to each instrumented vehicle. Four scientific reports pertaining to several experiments developed under this contract were published during the contract period [*Linford and Baker*, 1966; *Seljaas and Burt*, 1967; *Westlund and Littlefield*, 1967; *Alley et al.*, 1967]. These scientific reports thoroughly cover the instrumentation and application of these experiments. Where feasible, this report references the applicable scientific report and coverage is confined to a brief summary. The experiments not covered by scientific reports are thoroughly discussed in this report.

Table 1 provides a complete summary of the rockets, satellites, launch locations, launch dates, and experiments contained in each payload which were provided by the Upper Air Research Laboratory.

TABLE 1. Summary of Rocket Launchings and Experiments

Vehicle and Designation	Experiment and Instruments University of Utah	Launch Site	Launch Date Launch Time
Aerobee 150 3.614	*D-region, gyro interaction* Gyro heating transmitter Sensing wave receiver Difference frequency receiver Standing wave impedance probe Radiometer Relative radiated power monitor D-region propagation experiment Electron temperature probe	Eglin, Fla.	26 Aug 1965 1303 (local)
OV2-3 Satellite Titan III	*Electron density at synchronous orbit altitude* Standing wave impedance probe	Cape Kennedy, Fla.	21 Dec 1965
Javelin 19.191	*F-region irregularities* Downward pulse-phase exp. Electron temperature probe	Wallops, Island, Va.	28 June 1966 1223 (local)
Nike-Hydac Certification Round	*Solar eclipse* Standing wave impedance probe	Cassino, Brazil	5 Nov 1966 1155:21 (local)
Nike-Hydac D-4	*Solar eclipse* Langmuir probe Standing wave impedance probe	Cassino, Brazil	12 Nov 1966 1155:19 (local)
Nike-Hydac D-11	*Solar eclipse* Langmuir probe Standing wave impedance probe	Cassino, Brazil	12 Nov 1966 1208:37 (local)
Nike-Hydac D-13	*Solar eclipse* Langmuir probe Standing wave impedance probe	Cassino, Brazil	12 Nov 1966 1222:30 (local)
OV3-2 Satellite	*F-region* Standing wave impedance probe	Vandenberg AFB, Calif.	28 Nov 1966

AEROBEE 3.614

The strong interaction between radio waves and the ionosphere when excited in the vicinity of electron gyrofrequency has been denoted as gyro-interaction [*Bailey*, 1937a,b, 1938]. At this angular frequency given by $\omega_H = B\, e/m$, e/m is the electronic charge-to-mass ratio, B is the terrestrial magnetic field , the electrons spiral outward, reaching high velocities and huge displacements. If the radio wave is of sufficient strength, the resulting increased energy and collisions will cause noticeable heating and increased electron density by detachment from negative ions and by ionization of neutral molecules. These induced disturbances provide a technique for investigation of the D-region of the ionosphere where the relatively high, ambient, neutral particle density results in sufficient collisions to produce appreciable effects. In particular, the increased electron density and collisional frequency and their rate of decay to ambient provide valuable information on the rate coefficients for electron loss processes. An Aerobee rocket (3.614) was instrumented by Upper Air Research Laboratory to produce such a disturbance and provide a means of measuring the associated parameters. Table 1 lists the experiments contained in this rocket payload and some particulars pertaining to the vehicle launching. A complete documentation of experimental objectives, instrumentation and flight results appear in previous scientific reports [*Alley et al.*, 1967; *Westlund and Littlefield*, 1967].

SOLAR ECLIPSE ROCKETS AND PAYLOADS

In order to study electron and ion densities, ionizing radiation fluxes, and the resulting reaction rates in the D-region of the ionosphere during the total solar eclipse of 12 November 1966, instruments were carried aloft by four Nike-Hydac rockets launched from Cassino, Brazil. The four payloads were essentially identical. One, a payload certification round, was fired on 5 November 1966, and the three remaining rounds were fired during different phases of the eclipse on 12 November 1966. Table 2 lists launch dates, times, and locations along with other particulars for each vehicle. Complete documentation of the plan of attack, instrumentation, and other particulars concerning these four rockets was previously reported [*Sel?aas and Burt*, 1967].

TABLE 2. Launch Times for Eclipse Rockets

Rocket Designation	Launch Date	Launch Time* (Local Time)	Time from totality, min & sec	Approximate apogee, km
Certification Round	5 Nov 1966	1155:21	-	95.7
D-4	12 Nov 1966	1155:19	-16:00	115.0
D-11	12 Nov 1966	1208:37	-01:23	115.0
D-13	12 Nov 1966	1222:30	+12:30	115.0

*Local Time = Universal Time -2 hours

OV2-3 SYNCHRONOUS ORBITING SATELLITE

The OV2-3 satellite resulted from the developmental program for the Titan III rocket system. The satellite was designated as a secondary, non-interfering payload, and was to be carried into orbit during developmental tests of the Titan vehicle.

The primary mission objective of the OV2-3 spacecraft involved placing the spacecraft with its complement of scientific experiments into a near synchronous or geo-stationary, circular orbit (≈33,000 km) and accumulating the optimum amount of data from the onboard space environment sensors for the period of one year.

SCIENTIFIC PAYLOAD

Subsystems for the satellite were primarily assembled from the developed experiments that had been flight proven on previous programs. A standing wave impedance probe (SWIP), developed by Upper Air Research Laboratory, University of Utah, was included to measure electron density at the orbital altitude of the spacecraft. The instrument has yielded these measurements with a high degree of success in numerous rocket and satellite applications [*Baycock et al.*, 1964; *Ulwick et al.*, 1965; *Baker et al.*, 1967].

The SWIP measures electron density by determining the impedance changes of an antenna immersed in an ionized medium. The impedance is measured by applying RF signals to the antenna through a segmented, lumped constant, tapped delay line and measuring the tap point voltages. The information thus obtained, when telemetered to

ground, is sufficient to reconstruct the antenna standing wave, and hence to determine the antenna impedance, which is directly related to electron density in the medium local to the antenna. The standing wave impedance probe techniques and systems have been described in detail elsewhere [*Haycock and Baker*, 1961; *Ulwick et al.*, 1964]· however, the extreme altitude (≈33,000 km) of the planned orbit and the extended operating life requirement of the spacecraft dictated special application techniques and physical configurations to be used for this satellite instrument.

The anticipated range of plasma frequencies of the ionized medium to be investigated is the primary consideration when selecting RF frequencies to the greatest advantage on the SWIP antenna. The plasma frequency is directly related to the number of electrons per unit volume in the medium, and is given as

$$f_N = 9 \times 10^{-3} \times \sqrt{N}$$

where

f_N (plasma frequency) is in Mhz

N is number of electrons per cm^3

As can be seen from the graphic portrayal of the reactance of a dipole antenna immersed in a plasma in Figure 1, when the plasma frequency equals the antenna operating frequency f_o, a resonant condition is achieved wherein the reactance of the antenna changes from highly capacitive to highly inductive value.* Values of f_N above resonance will

*In actuality, the resonant frequency is shifted slightly due to the effect of the earth's magnetic field (a consideration that will be discussed shortly).

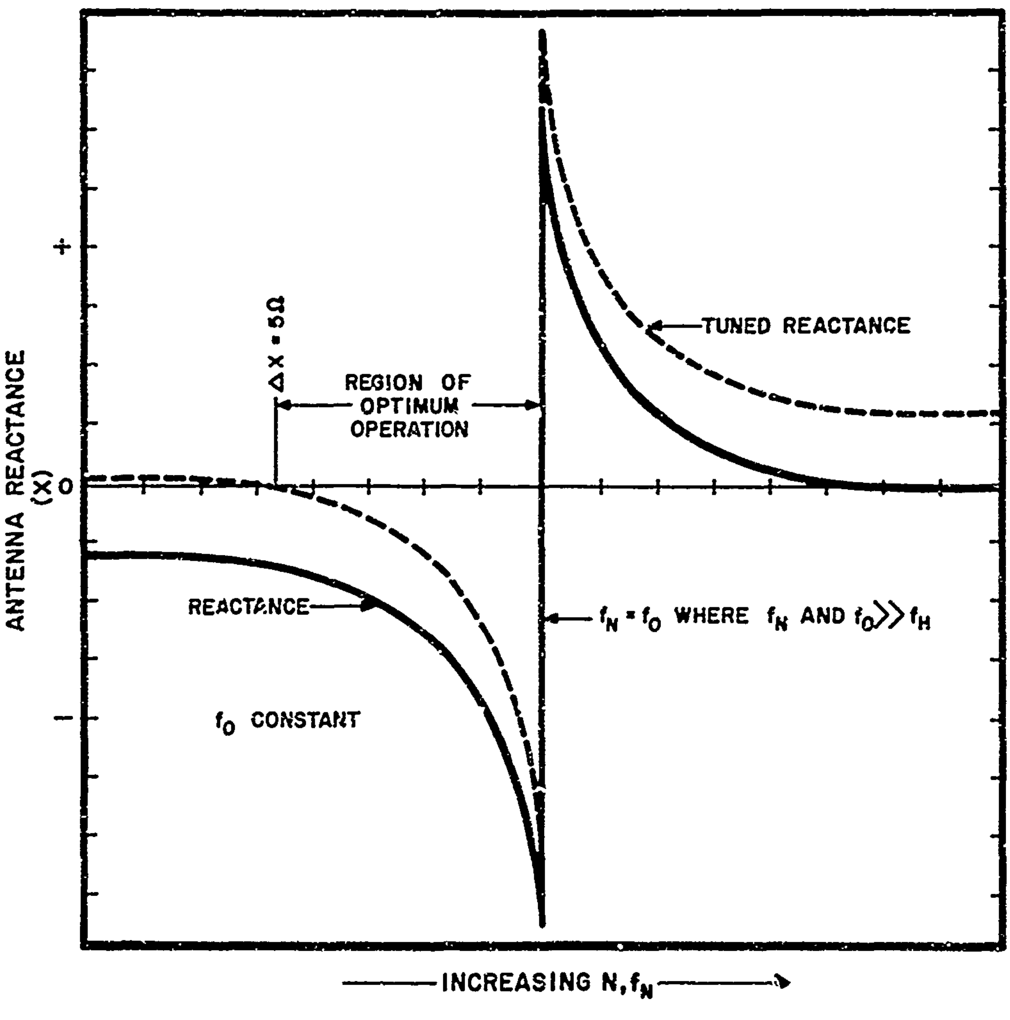

Fig. 1. Graphic portrayal of the reactance as a function of N of a dipole antenna immersed in a plasma and excited at a frequency (f_o).

result in positive antenna reactance whereas lower f_N will give capacitive values that are a direct function of f_N; and hence, measurements utilizing the negative reactance portion of the curve are most accurate and dictate use of operating frequencies above f_N, thereby reducing the physical size of the components. To achieve accurate measurements, it is necessary to reduce the magnitude of the impedance by shifting the reactance to some value nearer zero. This can be accomplished by adding an inductance in series with the antenna and shifting the reactance curve to those values indicated by the dotted line in the graph.

The useful area in the negative reactance region of the curve is also limited, however, because flattening of the curve as N decreases eventually creates a condition where even relatively large changes of N produce negligible changes in reactance. As N increases toward the point where $f_N = f_o$, however, larger reactance changes result with smaller N changes. A reactance change (ΔX) of 5 ohms is adequate for accurate measurements with the SWIP. This point, illustrated in Figure 1, on the graph indicates the smallest quantity of electrons that can be accurately measured in this application for a given frequency, and inversely, the highest frequency that will yield useful measurements for a fixed N. This, of course, limits the values of N that can be measured effectively by any particular f_o and, indeed, makes necessary an estimation of N before f_o can be assigned. The lowest useable frequency is dictated by f_N of the medium.

A rough estimation of N for the desired orbit was obtained from the information shown in Figure 2. The electron densities in the areas

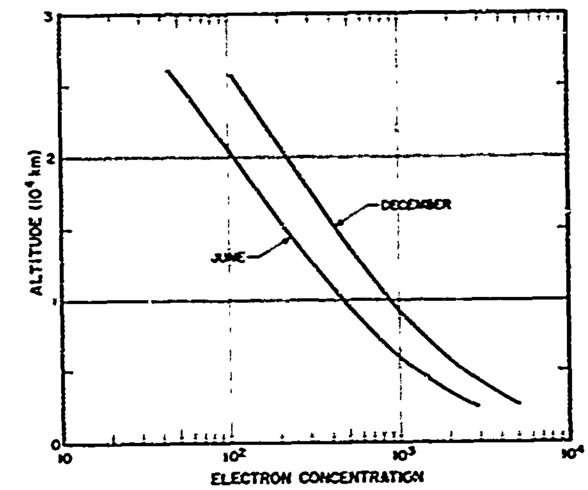

Fig. 2. Electron densities at high altitudes as derived from nose-whistler data.

shown have been determined from nose-whistler data [*Smith,* 1960]. Examination of the data for approximately 5 earth radii shows a value of approximately 30 electrons per cm^3. Insertion of this value into the formula for f_N yields an f_N at 5 earth radii of approximately 0.05 Mhz. Although data for the altitude with which the satellite is concerned is sparse, theoretical considerations indicate day-night variations on the order of a factor of 10 and also seasonal variations of similar magnitudes. Variations due to increased or decreased solar activity have also been postulated. The mission of OV2-3 would hopefully add to the existing data and provide an additional source of information.

An additional consideration when determining the f_o of the probe must take into account the gyro frequency f_H of the medium. If the operating frequency is not large compared to f_H, the accuracy may be impaired and a more complicated theory must be used.

The gyro frequency is given as

$$f_H = \frac{e}{2\pi m} B$$

where

e = electron charge

m = electronic mass

B = earth magnetic field

Since B decreases approximately as

$$B_o \left(\frac{R_o}{R_o + R}\right)^3$$

where B_o is the magnetic field measured at a reference distance R_o, it is noted that the magnetic field at 5 earth radii is greatly reduced from those values encountered at lower altitudes to a value of approximately 5 khz. This value is sufficiently below the f_N of the region so that it can be ignored in choosing the operating sequences.

Based upon the above considerations of f_N and f_H, two operating frequencies were assigned to the standing wave impedance probe; 0.3 Mhz and 0.6 Mhz were expected to provide adequate coverage of N variations in the orbital area.

Aside from the lower RF frequencies utilized on the probe, one additional deviation from usual application design was incorporated. This consisted of decreasing the rate of sampling the tapped line. At lower altitudes, aboard non-orbiting rocket payloads, high sampling

rates are necessary because of rapid fluctuations of electron density. At the OV2-3 satellite orbital altitude, however, only long term rates of change were expected, taking place over periods of several minutes or longer. For this reason, much lower sampling rates were considered adequate to detect the long term changes. These rates were set to sample the standing wave created by each frequency one time per minute during satellite operation periods.

Orientation of the probe electronics with respect to the satellite is shown in the drawing of Figure 3.

ELECTRONIC CIRCUITRY

A block diagram of the probe circuitry for the spacecraft is shown in Figure 4. The signals from the 0.6 Mhz and the 0.3 Mhz oscillators, shown in the block diagram, are alternately applied through the tapped, lumped constant delay line to the antenna for periods of 30 seconds each. Control of the oscillator switch, which alternately selects one of the two oscillator signals, is achieved through manipulation of the sync input pulse from the spacecraft commutator. This synchronizing pulse consists of a 0 to +10-volt square wave of one-second duration with a repetition rate of one pulse each 30 seconds. Two outputs are taken from the bistable multivibrator to control the oscillator switch. The output of the oscillator switch is an RF signal alternately of 0.3 Mhz or 0.6 Mhz. This signal is fed to the tapped lumped constant delay line and then to the antenna through the matching network which transforms the antenna reactance to a small value at the two frequencies.

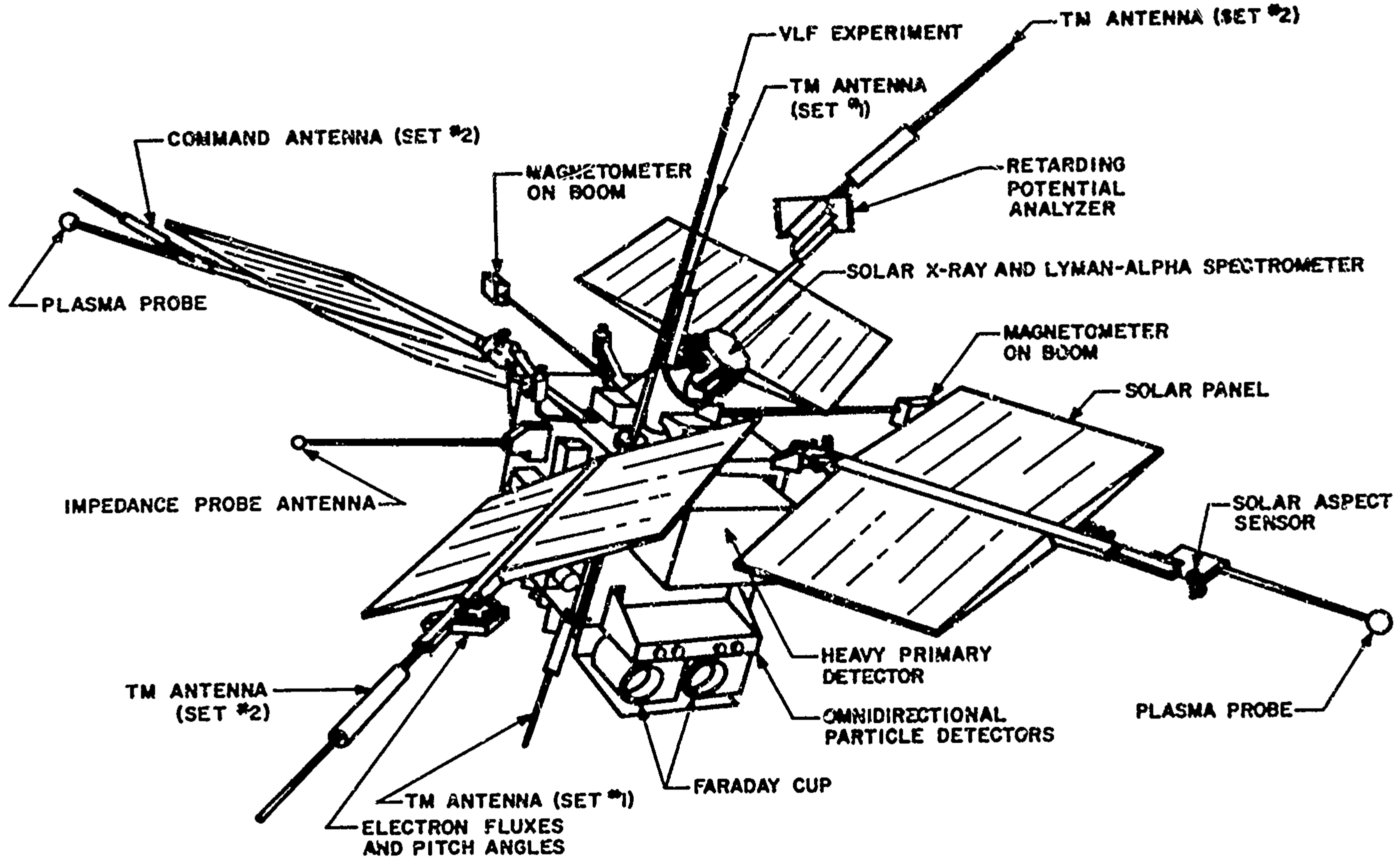

Fig. 3. Orientation of the standing wave impedance probe with respect to the satellite OV2-3.

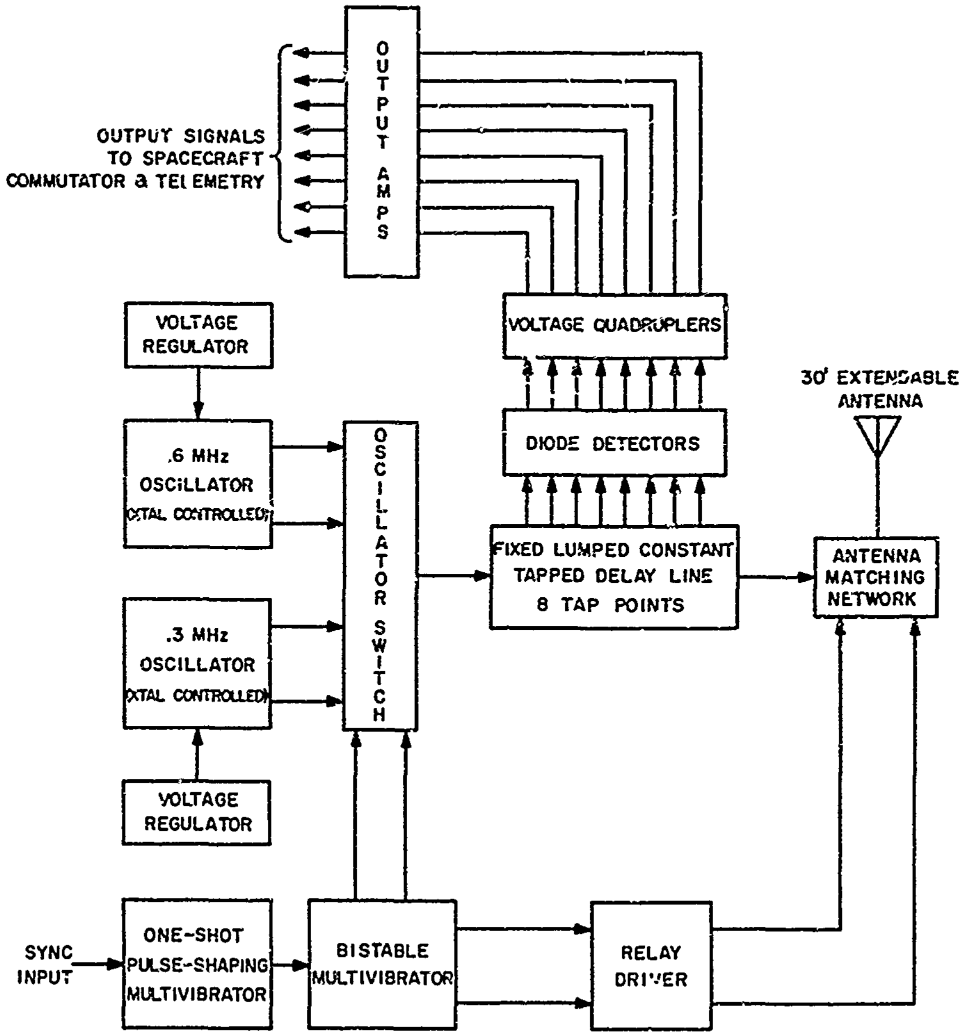

Fig. 4. Block diagram of OV2-3 standing wave impedance probe.

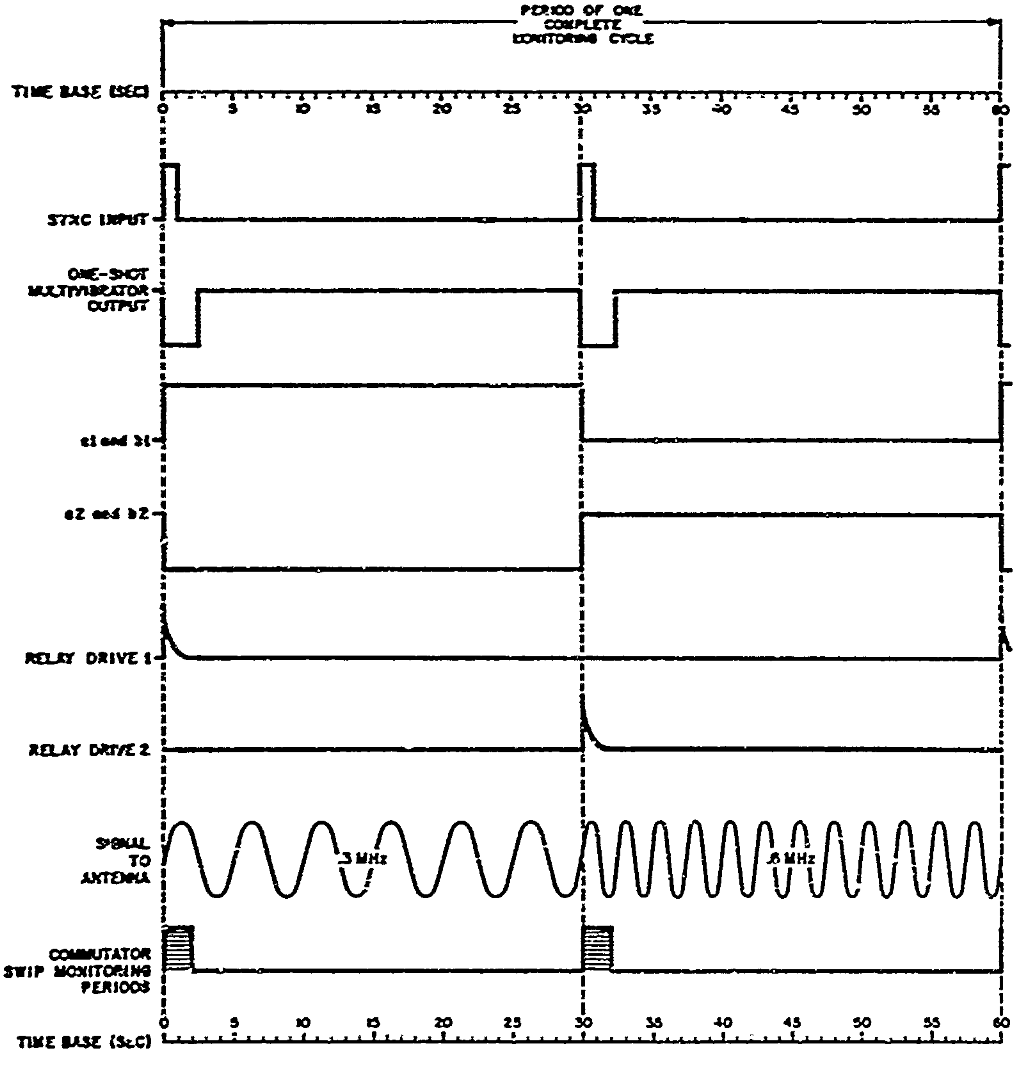

Fig. 5. Pulse configuration and time sequencing for the OV2-3 standing wave impedance probe.

The standing wave on the tapped line is monitored at eight points, diode rectified, amplified, and fed out of the probe to the spacecraft commutator and telemetry transmitter. Figure 5 is a portrayal of pulse configuration and time sequencing for the probe, and Figures 6, 7, and 8 are schematic diagrams of the probe.

The OV2-3 spacecraft configuration required that the probe antenna, which must be relatively long for the low operating frequencies, be an extendable type which could remain in the collapsed or folded configuration until the orbit of the spacecraft could be established; and then upon command, the antenna was to be extended to its full length. To accomplish this, the probe utilized the 30-foot De Havilland model A-18 antenna unit. The antenna is composed of an unfurling, beryllium copper element which is stored on a drum until extended. Principles of operation for the antenna unit are shown in Figure 9.

Calibration information for the OV2-3 standing wave impedance probe are included in Appendix A.

LAUNCH AND FLIGHT RESULTS

On 21 December 1965, the Titan vehicle carrying the OV2-3 spacecraft was launched from Cape Kennedy, Florida. Proper orbit of the satellite was not established, the satellite was not located; and it is assumed that the spacecraft failed to orbit.

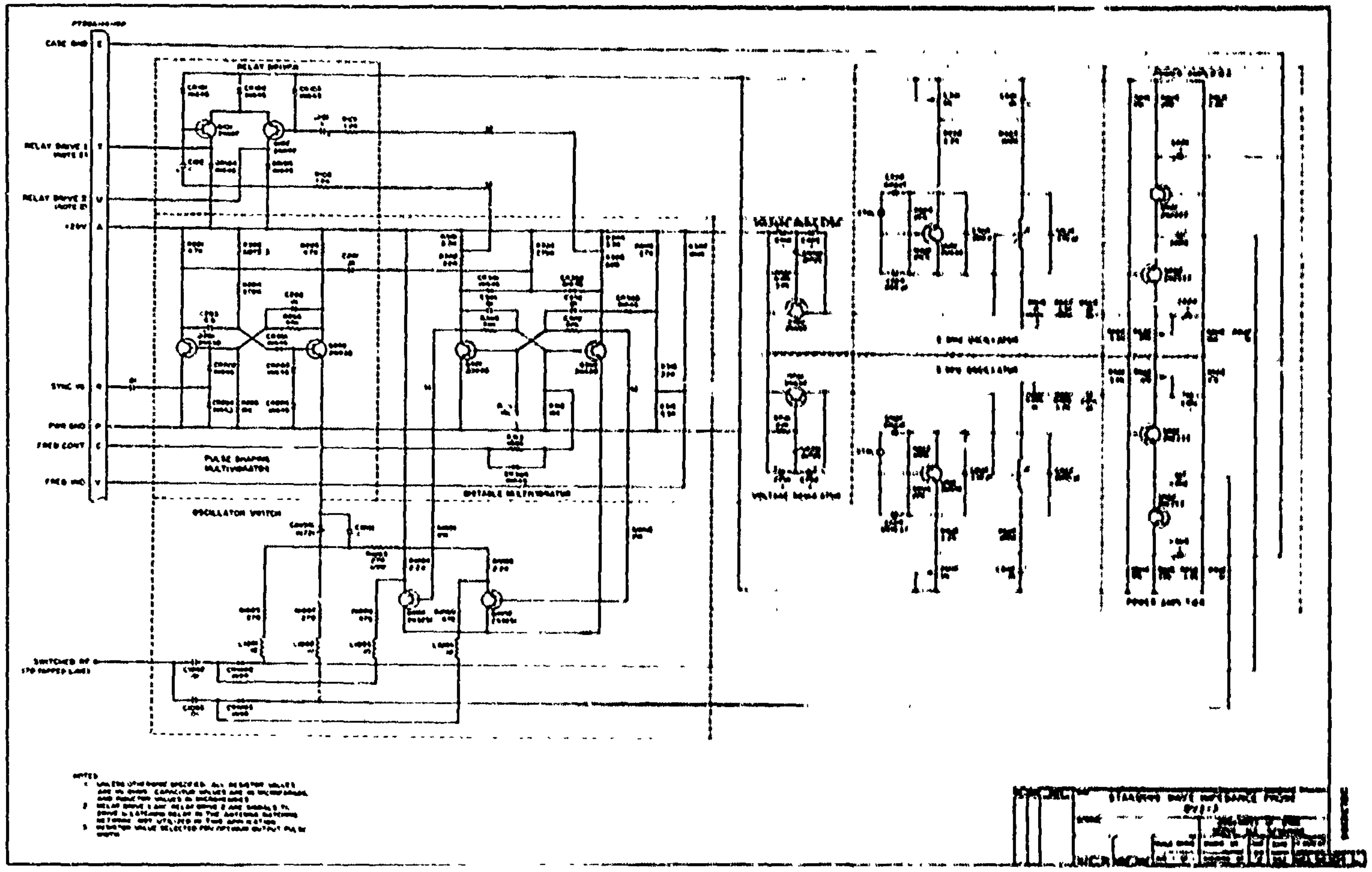

Fig. 6. Schematic diagram of electronics for OV2-3 standing wave impedance probe.

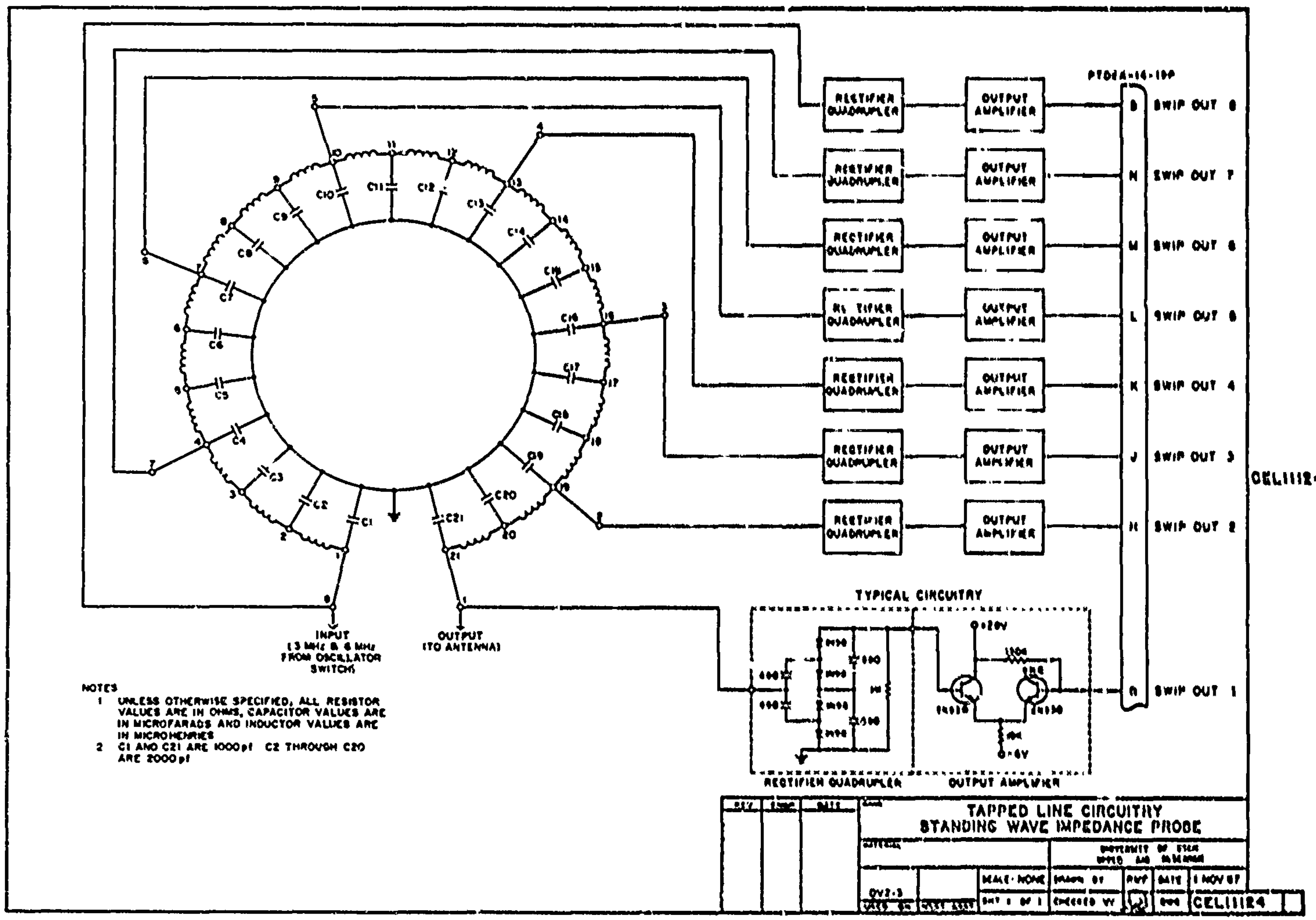

Fig. 7. Fixed tapped line and associated circuitry for OV2-3 standing wave impedance probe.

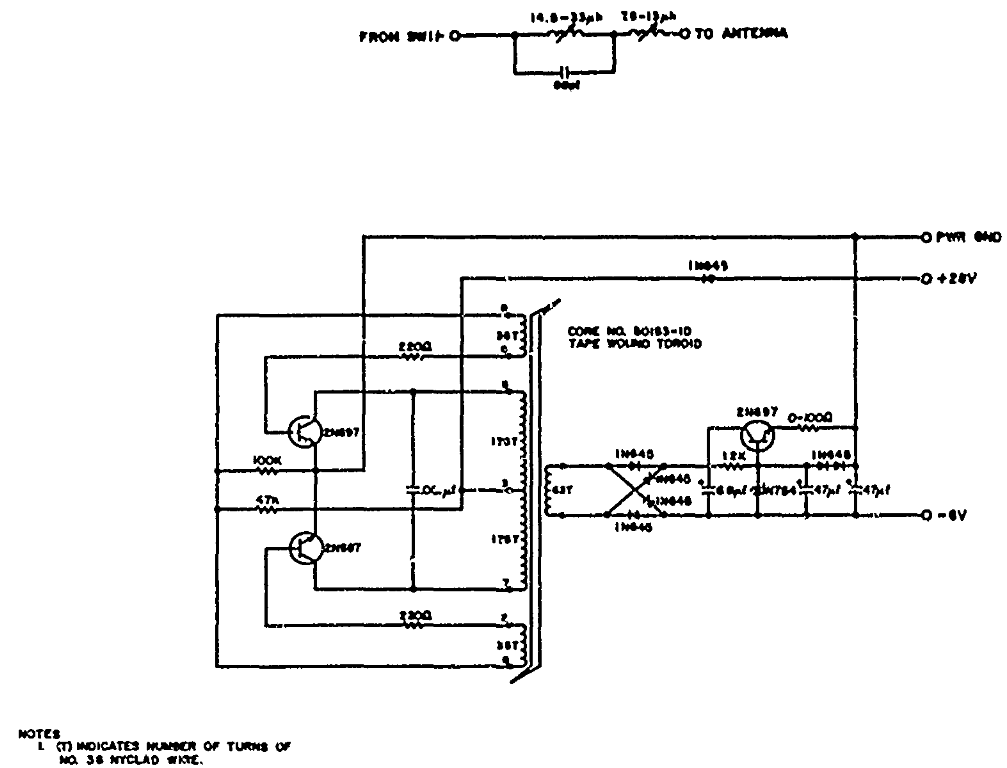

Fig. 8. 6-volt regulated supply and antenna matching network for OV2-3 standing wave impedance probe.

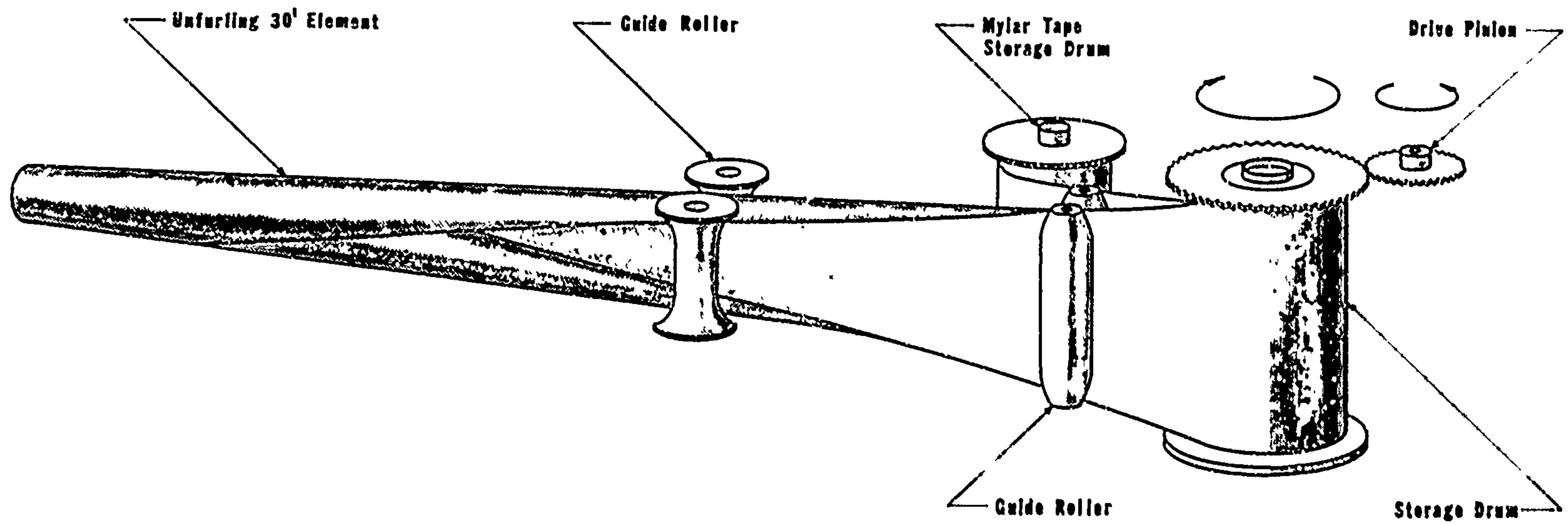

Fig. 9. Principles of operation for OV2-3 standing wave impedance probe antenna.

OV3-2 SATELLITE

The OV3-2 satellite was designed to be carried into orbit from Vandenberg Air Force Base, California, by a Blue Scout rocket. The satellite incorporated a standing wave impedance probe developed by Upper Air Research Laboratory, University of Utah. The purpose of the probe was to provide measurements of electron density local to the orbiting satellite in the ionospheric F-region. The planned orbit for the satellite was nearly polar and included an apogee and perigee of approximately 1760 and 250 km, respectively. The orbit made the satellite particularly useful for studies of high altitude auroral effects. The probe operating frequencies were set at 2.0 and 7.2 Mhz to encompass the expected electron density variations.

A block diagram of the standing wave impedance probe used on this satellite is shown in Figure 10, and the timing sequence is included in Figure 11. The probe is similar in many respects to that incorporated in the OV2-3 system, but there are some significant differences between the two probes.

In contrast to the OV2-3 probe, which was concerned primarily with measuring fine scale, long term deviations in electron density from its geo-stationary position, the OV3-2 probe operated at much lower altitudes and was primarily concerned with detecting faster and larger magnitude ionospheric cross-sectional deviations in electron density. Because of the lower orbit and differences in apogee and perigee, expected electron density values were greater and hence the deviations were far greater. These conditions combined to create a need for much

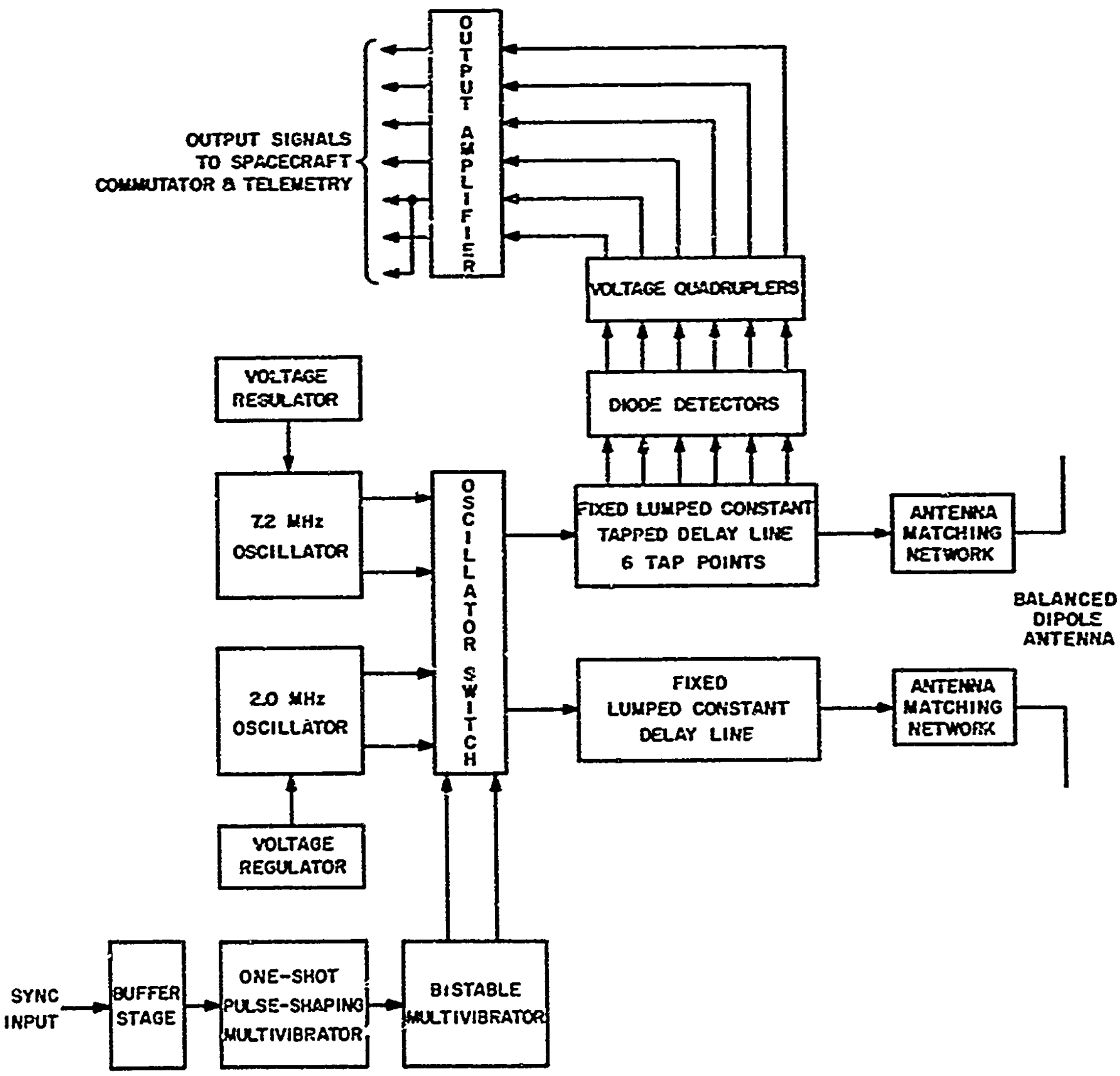

Fig. 10. Block diagram of OV3-2 standing wave impedance probe.

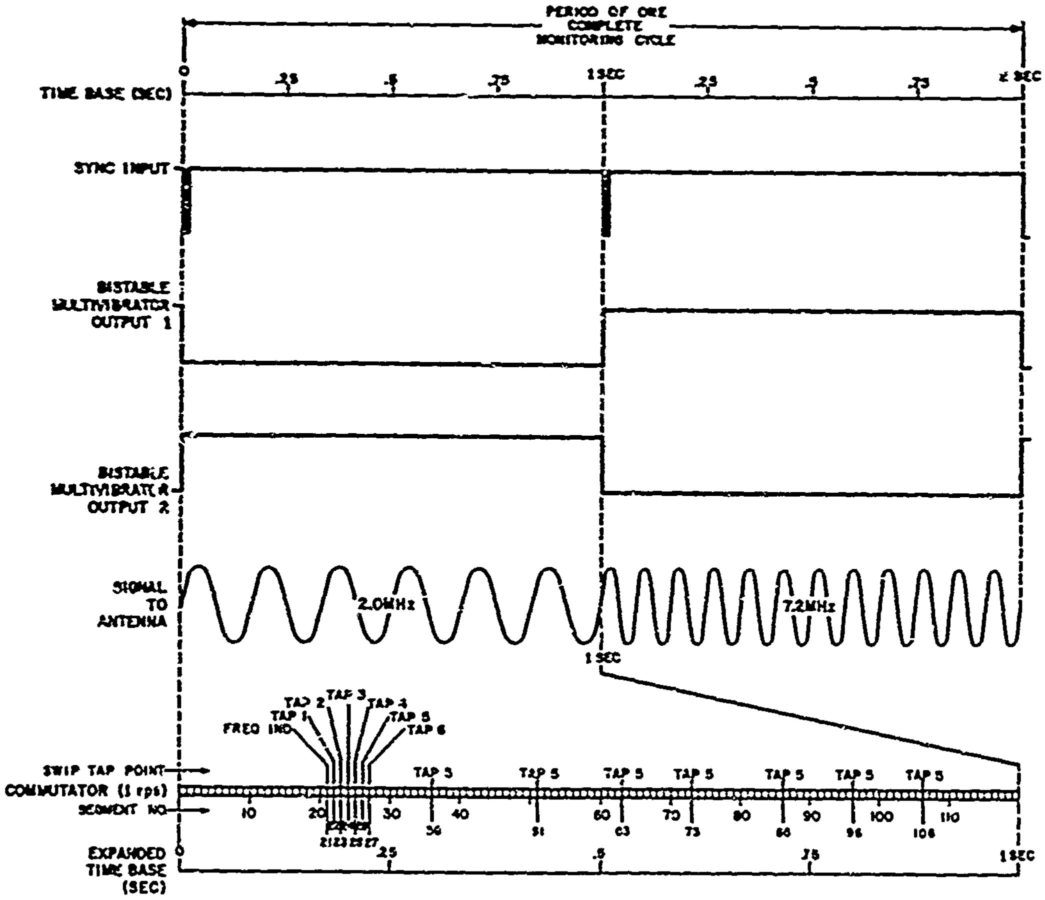

Fig. 11. Pulse configuration and timing sequence for OV3-2 standing wave impedance probe.

higher operating frequencies in order to maintain operation on the desired portion of the reactance curve and also necessitated the use of faster sampling rates in order to adequately monitor electron density.

To facilitate the need for faster sampling rates, a scheme for monitoring the standing wave impedance probe was devised which permitted sampling the standing wave as often as possible. The spacecraft commutator to which the probe was assigned was a 120 segment, one revolution per second device. The switching rate for the probe was controlled by the commutator, i.e., 2.0 Mhz for one second, 7.2 Mhz for one second. The tapped delay line for the probe provided six monitoring points for inclusion on the commutator in the normal fashion; however, this allowed only one sample of the complete standing wave each second. To provide a higher measuring rate, seven additional monitoring segments were provided on the 120-segment commutator. The fifth tap point of the delay line was tied to each of these seven segments. Therefore, each complete commutator revolution provided a complete monitor of the standing wave and seven additional indications of the voltage present at the fifth tap. By referencing these additional, fifth tap point voltage indications to the complete monitor of the standing wave, a more comprehensive monitor of fine scale deviations in electron density is provided. The time sequencing of the commutator sampling configuration is shown as a portion of Figure 11.

Another contrast with the OV2-3 probe is provided by the fact that the OV3-2 instrument utilized a balanced dipole antenna rather than a

single unbalanced unit as on OV2-3. This aspect complicates the circuitry slightly but simplified calculation of free space antenna impedance. In the balanced dipole application, the locus of all the zero potential points in the space surrounding the payload is a plane perpendicular to the axis of the antenna through the axis of the payload. This situation can be easily recreated for measuring antenna impedance during preflight calibration [*Linford and Baker*, 1966].

Finally, the OV3-2 satellite utilized a tape recorder which, upon command, was capable of recording data during a complete orbit, then replaying and transmitting the accumulated data upon command during a pass over a control station. Also, the satellite incorporated facilities for monitoring and transmitting data on a real time basis. This real time function, however, must be accomplished within the transmitting and receiving range of a command station.

The overall electronic circuitry for the OV3-2 standing wave impedance probe is included in Figures 12 through 15. The two matching networks, one at each antenna, were designed to accomodate both the 2.0 and 7.2 Mhz output signals and are shown as a portion of Figure 15.

Although this unit utilized two antennas, they were of the same type utilized on OV2-3, i.e., the 30-foot De Havilland A-18 design, as shown in Figure 9.

Complete calibration documentation for the OV3-2 SWIP is contained in Appendix B.

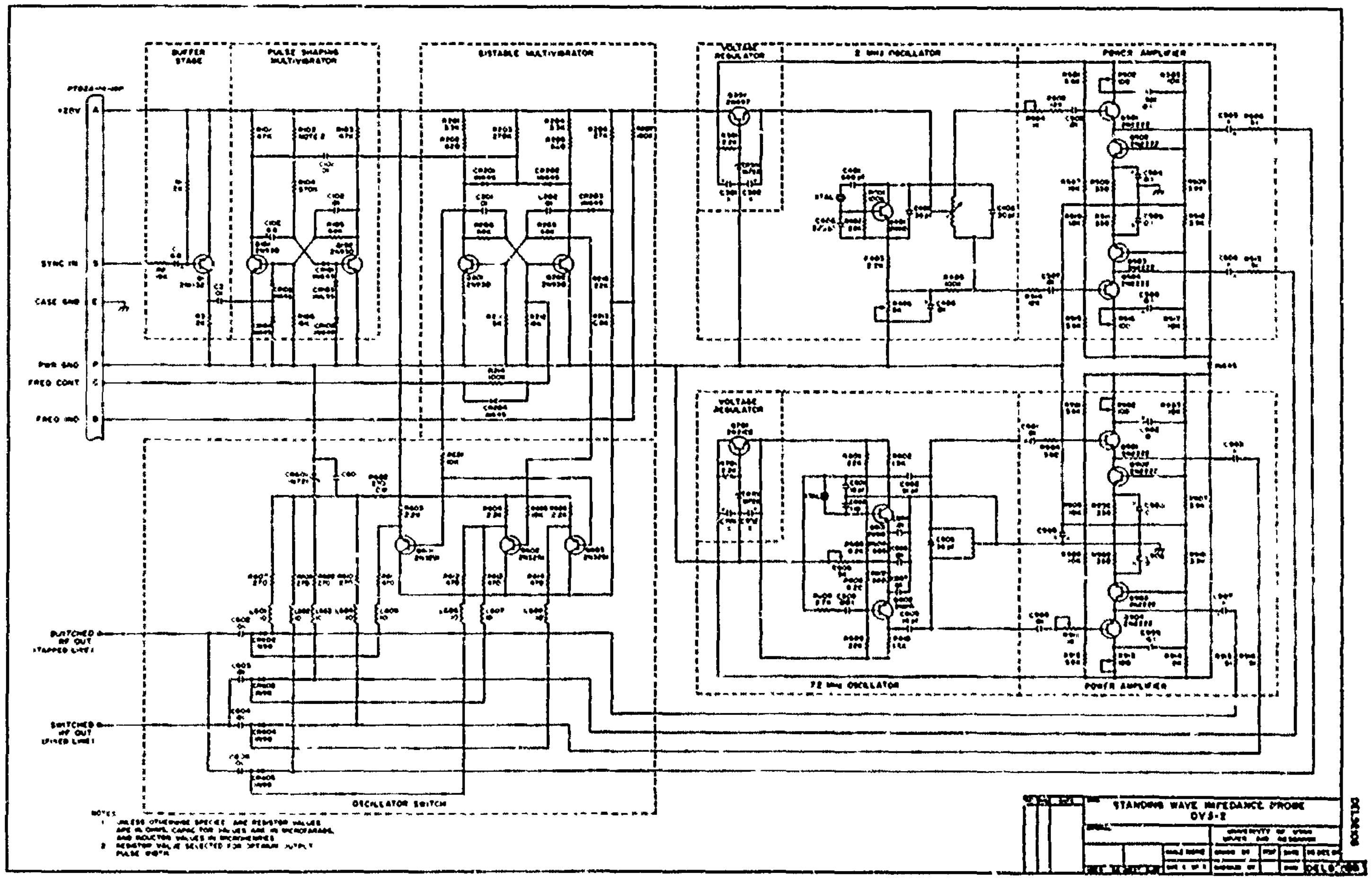

Fig. 12. Schematic diagram of electronics for OV3-2 standing wave impedance probe.

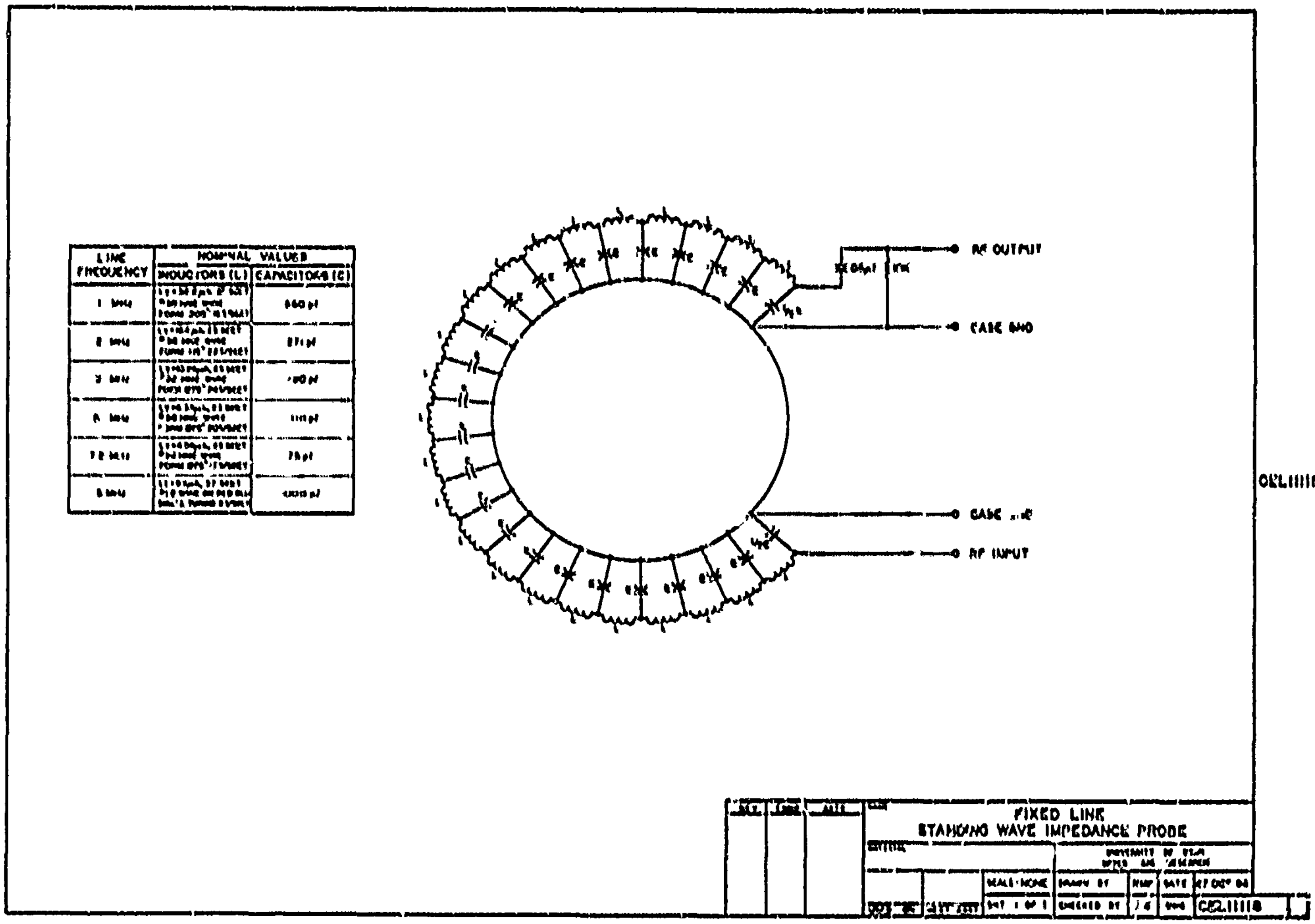

Fig. 13. Fixed delay line for OV3-2 standing wave impedance probe.

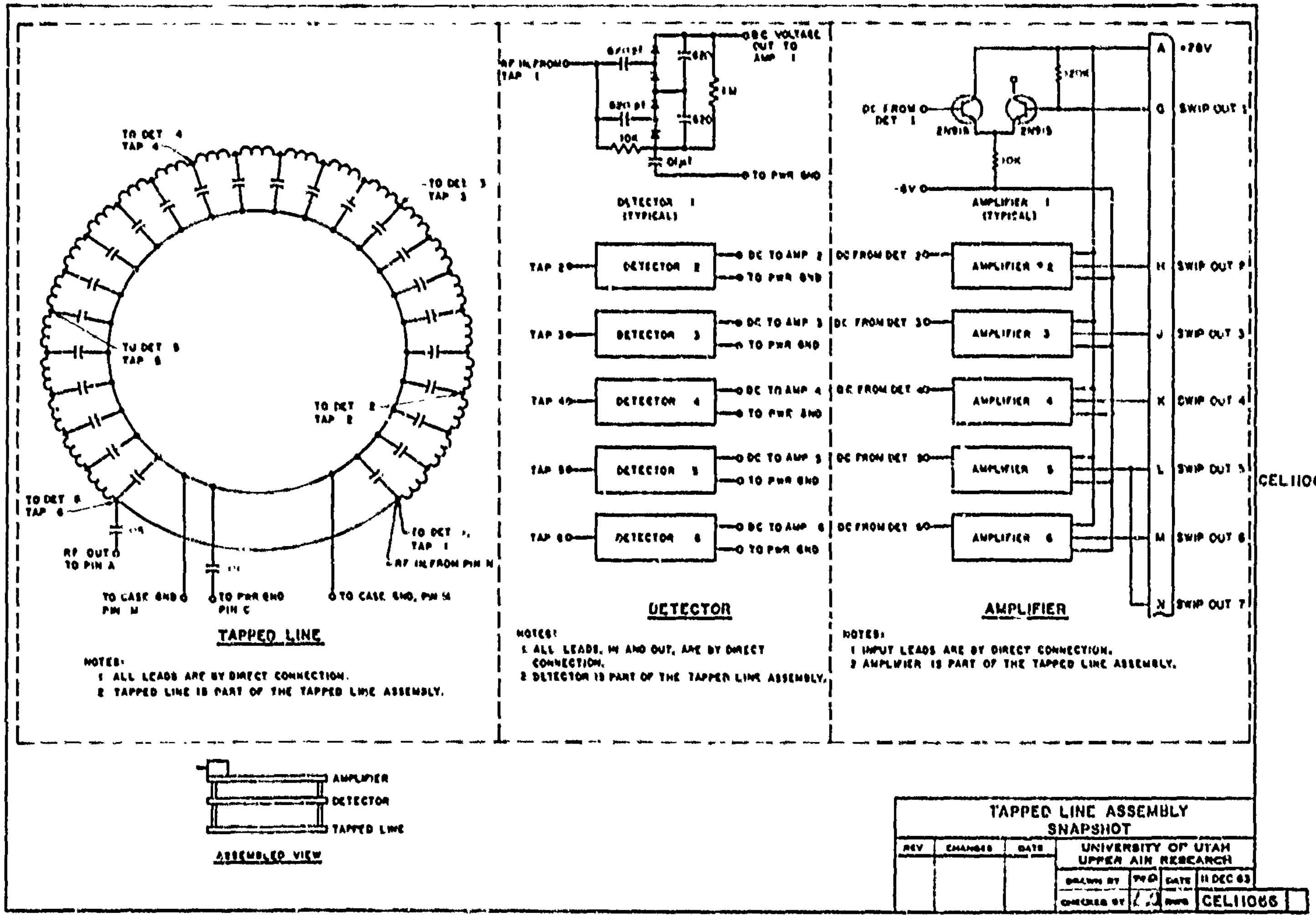

Fig. 14. Fixed tapped delay line and associated circuitry for OV3-2 standing wave impedance probe.

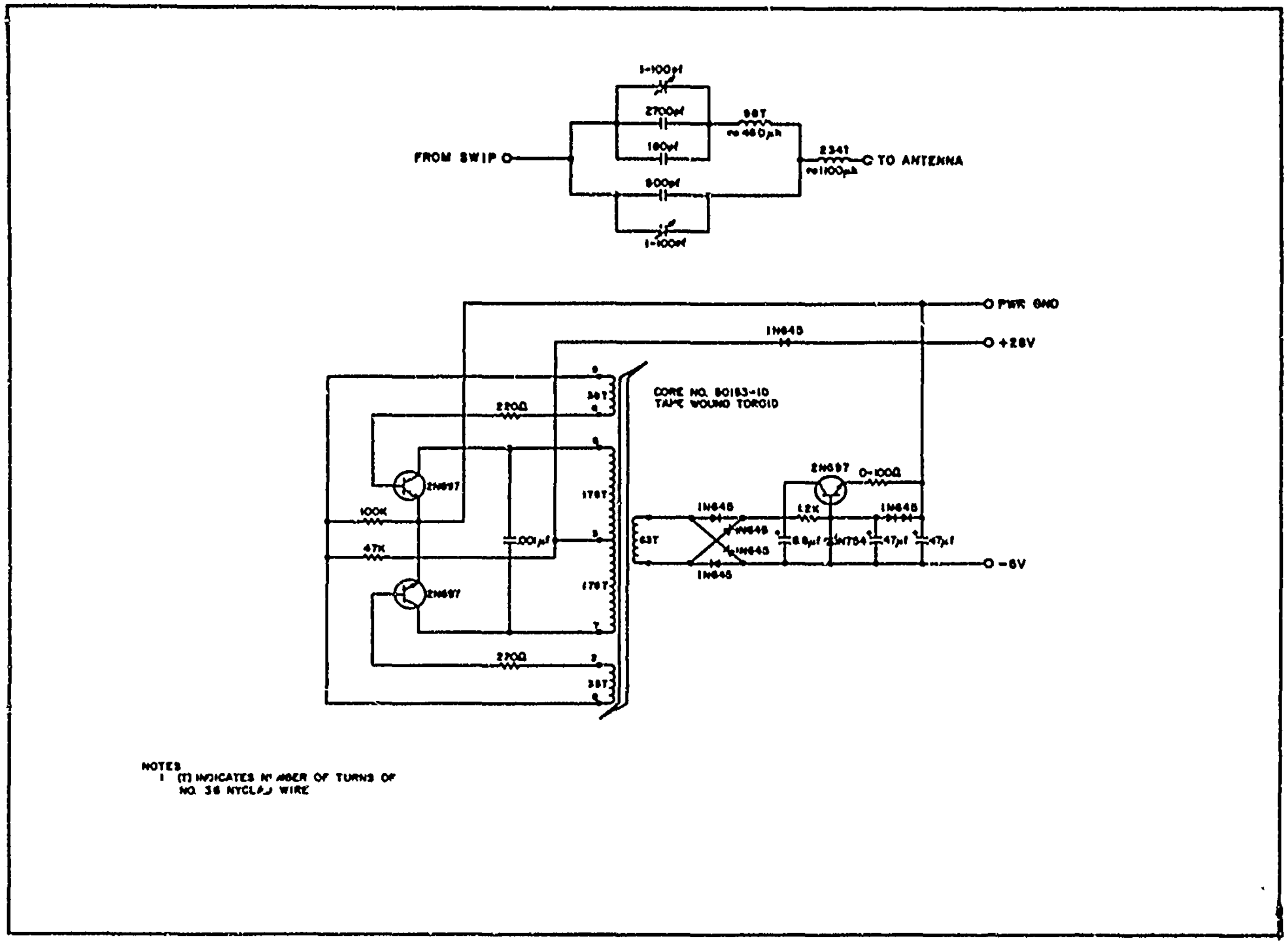

Fig. 15. 6-volt regulated supply and antenna matching network for OV3-2 standing wave impedance probe.

OV3-2 LAUNCH AND FLIGHT RESULTS

The Blue Scout rocket employed to orbit this satellite was launched from Vandenberg Air Force Base on 28 October 1966. A satisfactory polar orbit with an inclination of 82° and apogee and perigee of 1597 km and 320 km, respectively, was established for the spacecraft. A malfunction in the satellite command system prevented the standing wave impedance probe from operating during the first week of the satellite's lifetime; however, a way of circumventing the abnormal logic circuitry was found and power was applied to the impedance probe. Preliminary and subsequent reports indicate that the impedance probe is functioning normally and useful data pertaining to electron density local to the spacecraft are being accumulated. At the time of this writing, the SWIP is still providing good data on a real time basis; however, a malfunction in the tape recorder has eliminated the stored data function. Real time data depends upon the presence of a ground control receiving station, and this aspect of the real time function limits the areas where the measuring capabilities of the instrumented spacecraft may be applied.

JAVELIN 19.191

This rocket payload was designed to measure fine-scale fluctuations of electron density and temperature in the quiet F-region of the ionosphere. To achieve this objective, the instrumentation was to be carried into the F-region by the four-stage Javelin rocket shown in Figures 16 and 17. Predicted vehicle trajectory for an effective launch elevation of 80° gave an apogee of 620 km. After leaving the dense portion of the atmosphere, the payload heat shield would be ejected, antennas deployed, and the operating payload would then independently perform measurements of electron density and temperature local to the rocket. The two widely spaced ground stations, one located at the Wallops Island launch site and the second down range at Bermuda, permitted simultaneous, cross-sectional views of the ionosphere.

The rocket payload was comprised of three experiments developed by the University of Utah to achieve the desired measurements:

1. Pulse-phase delay experiment (prime experiment)
2. Standing wave impedance probe
3. Stepped electron temperature probe

Other instrumentation was included aboard the vehicle for measuring payload aspect, initiating and implementing timing sequences, and two telemetry links. Although the above instruments and their related antennas were designed and built by University of Utah personnel, integracion of the vehicle payload was under the direct supervision of AFCRL engineers. Instrument locations aboard the payload and the nose cone heat shield are shown in Figures 18 and 19. Table 3 includes time functions and related parameters.

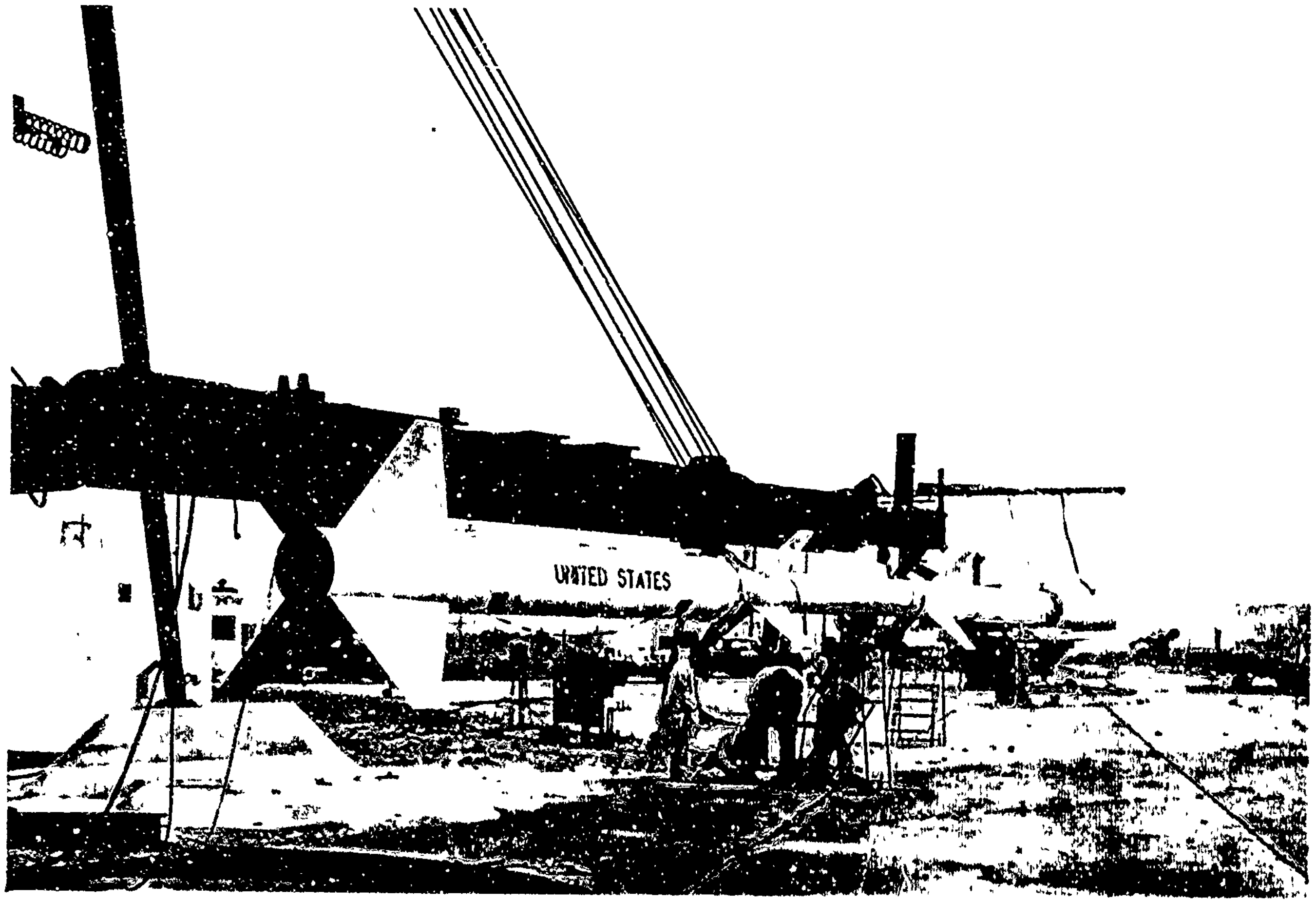

Fig. 16. Photograph of Javelin 19.191 mounted on launcher.

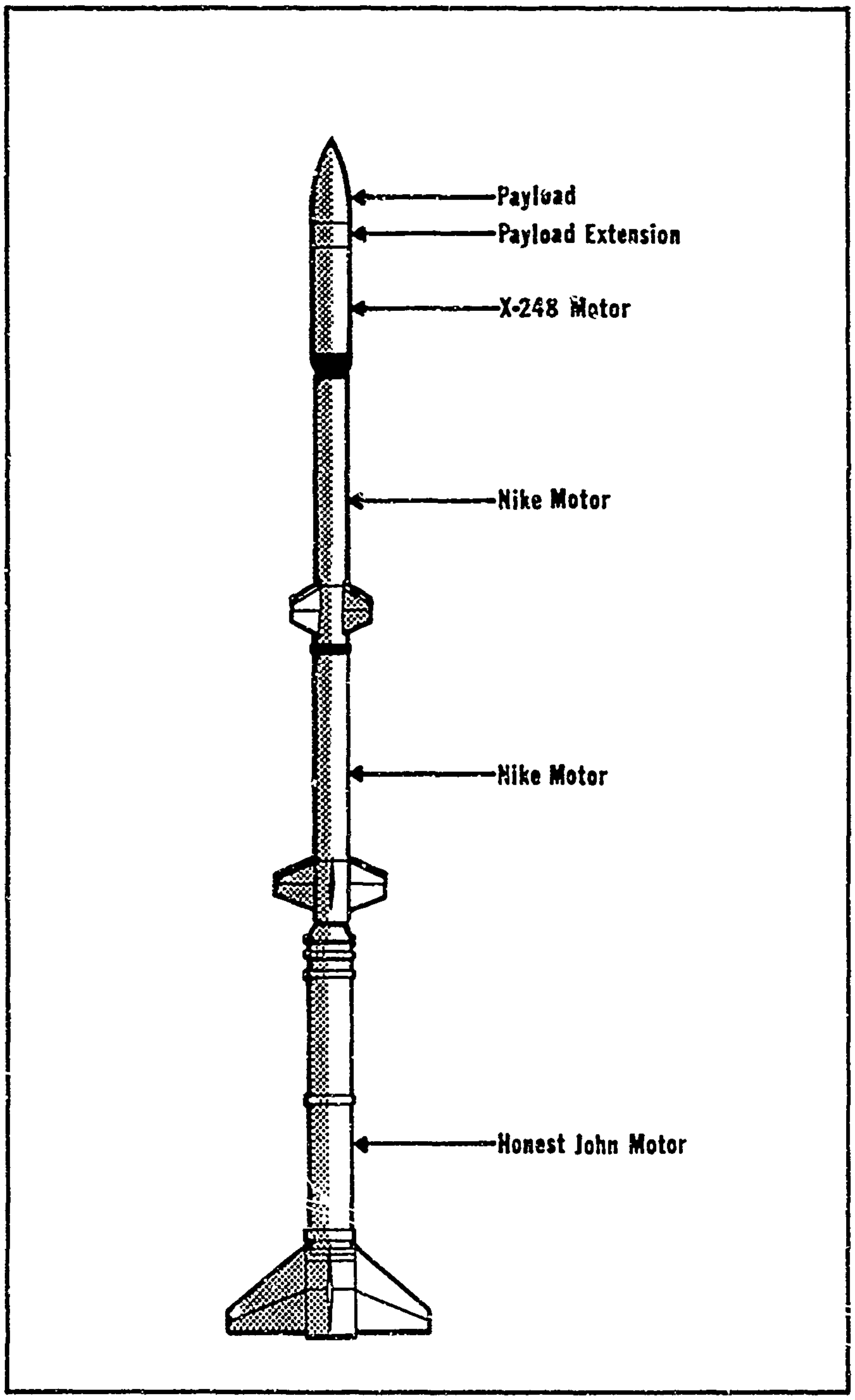

Fig. 17. Outline of Javelin 19.191.

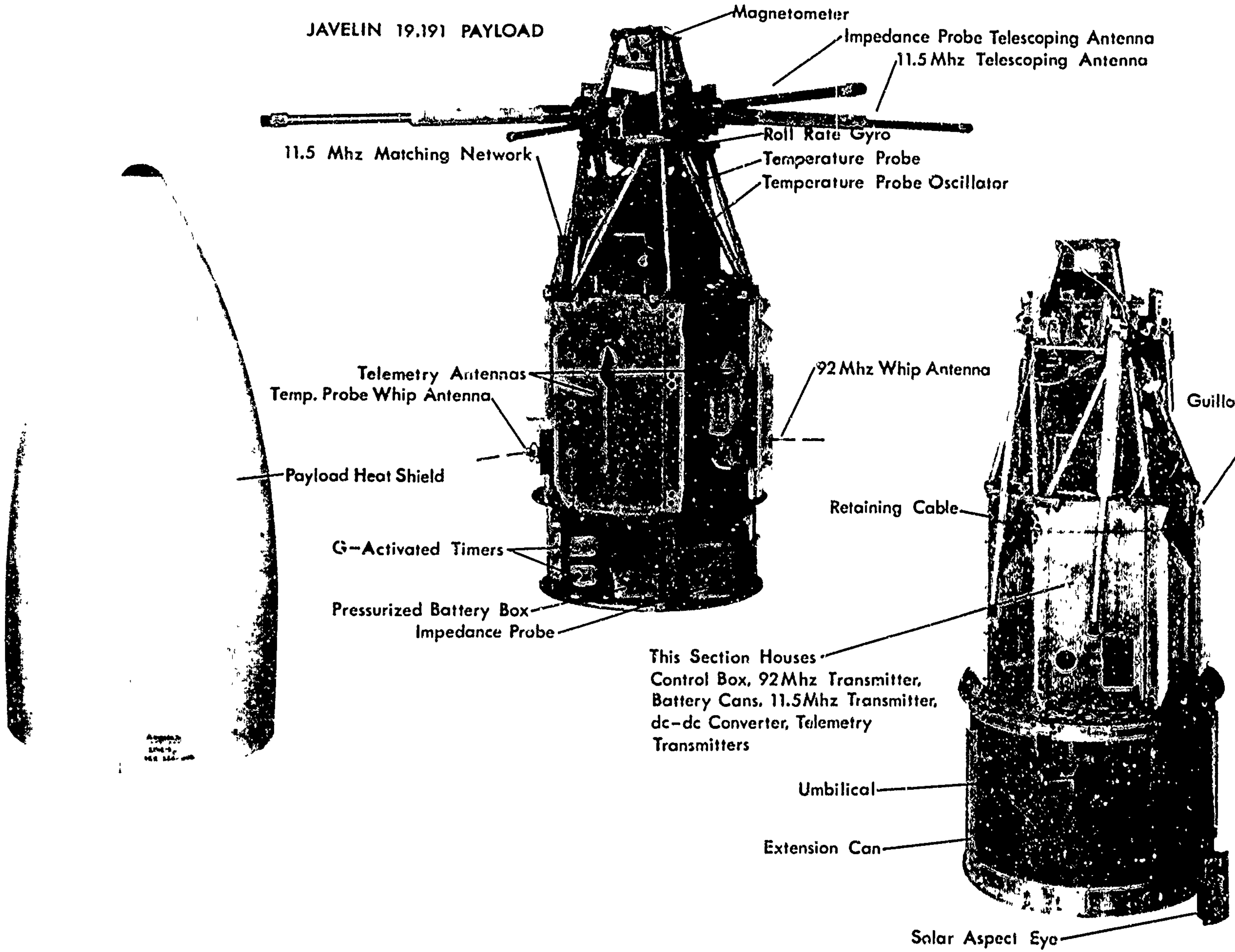

Fig. 18. Javelin 19.191 instrument locations.

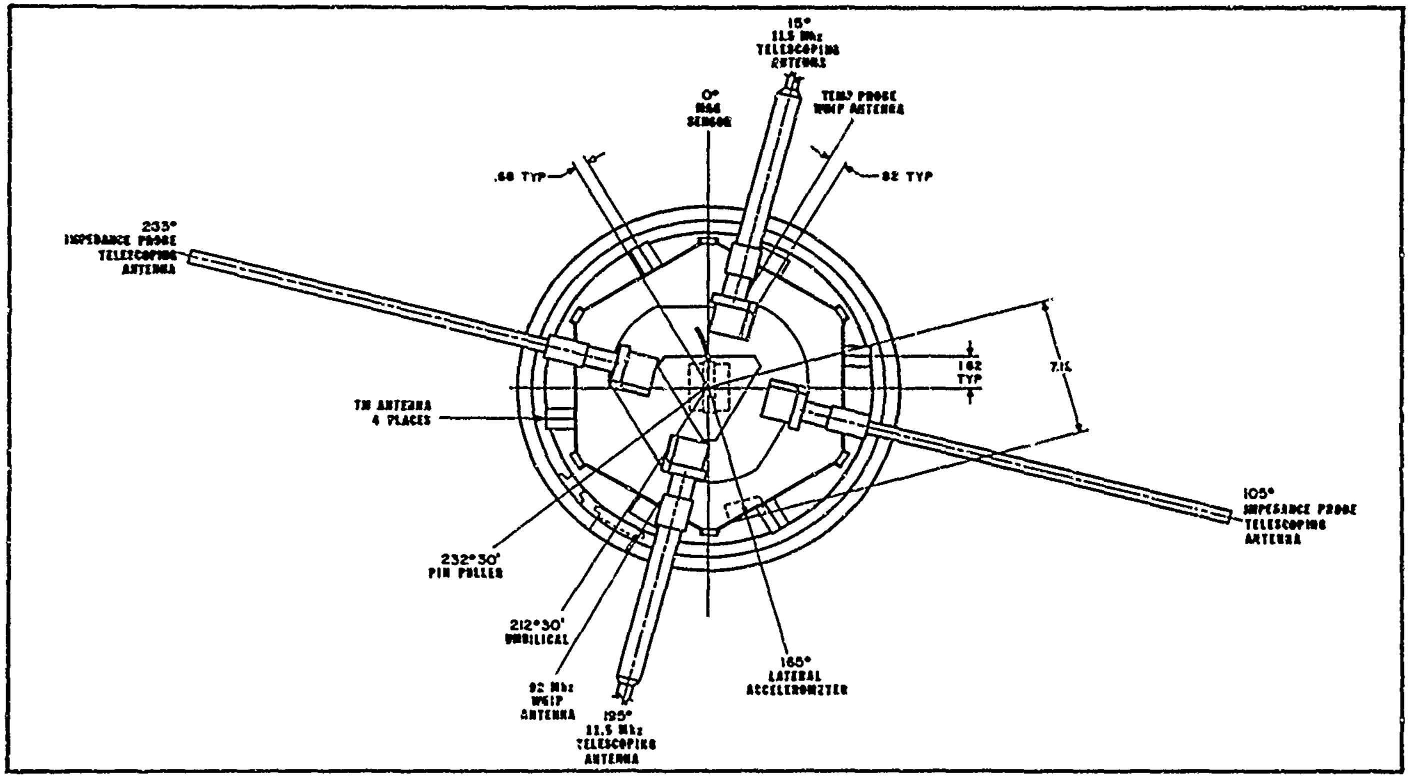

Fig. 19. Javelin 19.191 antenna and instrument locations.

TABLE 3. Timed Functions* for Javelin 19.191

Event	Time (sec)	Altitude (km)	Velocity (fps)
First stage ignition (Honest John)	0	0	0
First stage burnout (drag separated from first)	4.8	1.2	1647
Second stage ignition (Nike)	9.7	3.4	1310
Unlatch pin fired	11.7	X	X
Second stage burnout (drag separated from third)	13.0	5.4	2630
Third stage ignition (Nike)	25.0	13.0	1808
Third stage burnout (roll rate = 7 (rps)	28.35	16.1	4384
Fourth stage ignition (X-248) (blow out diaphram separate from third)	60.0	49.5	3156
Fourth stage heat shield release	62.0	X	X
Fourth stage burnout	101.4	120.1	10,827
Payload heat shield eject.	126.4	191.5	10,143
Antenna erection	131.4	X	X
Fourth stage apogee	448.0	622.3	4736
Fourth stage impact	896	0	X

*Information is predicted performance

EXPERIMENTS

Pulse-Phase Delay

The pulse-phase experiment was employed to determine integrated electron density between the rocket and the ground stations. Electron density is related to the group delay and phase velocity of RF pulses transmitted from the rocket and is attained by measuring these parameters. To obtain the measurements, the transit time and phase velocity of probing signals near the critical frequency of the ionospheric layer under investigation are compared with those of a much higher frequency reference signal which suffer negligible effects during transit. This system, including the two associated ground stations, has been discussed in detail in a previous report [*Baker and Allred*, 1965].

The major portion of the pulse-phase experiment remained unchanged from the system described in that report, but design changes were made to the 92-Mhz transmitter after the report publication date. As previously designed, the 92-Mhz transmitter proved very unstable when exposed to changes in temperature. This condition was corrected by completely re-designing the transistorized portion of the transmitter. A schematic diagram of the newer transmitter design is shown in Figure 20.

The transistor doublers and amplifier were changed from a common base configuration to a common emitter design. Both parallel and series tuned circuits were incorporated to isolate the desired signal from the different harmonics in the doubler and quadrupler. The tube output stages remained unchanged except that an improved physical layout was used throughout.

This new model proved superior to previous designs and was highly satisfactory in providing a stable CW output of 18 watts.

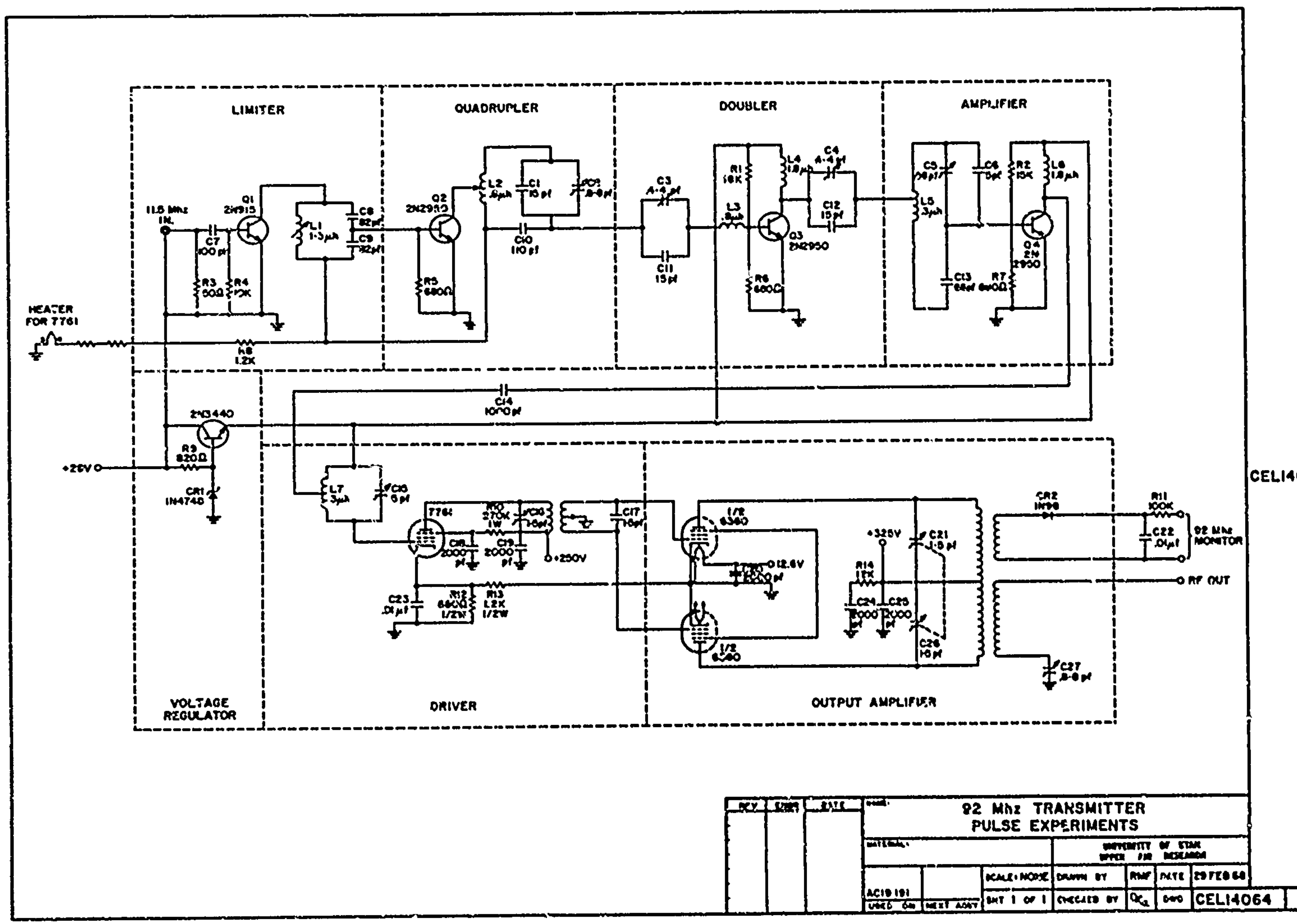

Fig. 20. Schematic of 92-Mhz transmitter.

Standing Wave Impedance Probe

The standing wave impedance probe included in the Javelin payload to provide local electron density measurements operated at frequencies of 3.0 and 7.2 Mhz. This instrument was essentially identical to the unit included in the payload of scientific passenger pod, capsule N-33 [*Baycock et al.*, 1965]; and since there was no major modification of this instrument, reference is made to the above report for documentation. Complete calibration for this probe is given in Appendix C.

Step Electron Temperature Probe

The step electron temperature probe was identical to the unit contained in scientific passenger pod, capsule N-25 [*Baycock et al.*, 1965] with the exception that the associated plasma frequency probe electronics were replaced by the plasma sweep oscillator and an antenna current monitor. In all other respects the probe was identical to that of capsule N-25; and for documentation, the reader is referred to that report. Complete calibration data for the instrument is included in Appendix C.

The antenna current monitor mentioned in the preceding paragraph consisted of a current transformer at the antenna of the step electron temperature probe, and an amplifier to condition the signal for telemetry transmission.

TELEMETRY

Two 4-watt FM/FM telemetry transmitters were included in the vehicle. Channel assignments and commutator assignments for the two transmitters are given in Tables 4 through 6.

TABLE 4. Telemetry Assignments - 19.191

Link 1 - 240.2 Mhz		
100-khz signal pulse modulated at 100 hz with 5-millisecond pulse		
Link 2 - 231.4 Mhz		
IRIG Channel	**Frequency (khz)**	**Data Description**
18	70.0	Temp. probe data
17	52.5	RF current
16	40.0	10 x 30 IRIG impedance probe
15	30.0	Fine frequency
14	22.0	10 x 30 IRIG monitor commutator
13	14.5	Temp. probe gain monitor
12	10.5	Housekeeping commutator
8	3.0	Long. accelerometer
7	2.3	Roll rate gyro
6	1.7	Lat. accelerometer
5	1.3	Magnetometer

TABLE 5. Monitor Commutator Data Assignments - 19.191

10 x 30 IRIG	IRIG Channel 14	22 khz

Channel	Data
1	+0 volts calibration
2	+5 volts calibration
3	+2.5 volts calibration
4	Temperature antenna voltage
5	Temp. mode indicator 1
6	Plasma readout 1
7	Plasma readout 2
8	Plasma readout 3
9	Temp. fine frequency
10	S. T. 1
11	S. T. 2
12	Pulse-phase TM 1
13	Plasma readout 3
14	Pulse-phase TM 2
15	Pulse-phase TM 3
16	Temp. antenna voltage
17	Temp. mode indicator 2
18	Plasma readout 3
19	Pulse-phase TM 4 (92 Mhz nf)
20	Antenna 1 position
21	Antenna 2 position
22	Temp. fine frequency
23	Plasma readout 3
24	Antenna 3 position
25	Antenna 4 position
26	S. T. 1
27	S. T. 2
28	Plasma readout 3
29	Frame readout +5 v
30	Frame readout +5 v

TABLE 6. Housekeeping Commutator Data Assignments - 19.191

2.5 x 30 IRIG	IRIG Channel 12 10.5 khz
Channel	**Data**
1	Radial accelerometer
2	Aspect eye temp. #3
3	Aspect eye temp. #4
4	Aspect eye temp. #5
5	B+ monitor for radial accel.
6	Radial accelerometer
7	Aspect eye voltage cal.
8	Nose cone mon. pull pins
9	Longitudinal accelerometer
10	Temperature ckt. calibration
11	Radial accelerometer
12	Temp. #1 (battery box)
13	Temp. #2 (T/M XMTR)
14	Temp. #3 (payload side)
15	Temp. #4 (top of deck #1)
16	Radial accelerometer
17	Temp. #5 (bottom of deck #1)
18	5v calibration
19	2.5v calibration
20	0v calibration (gnd.)
21	Radial accelerometer
22	Nose cone mon. #1, 0°, 90°
23	Nose cone mon. #2, +45° -45°
24	Long. accelerometer
25	B+ monitor for long. accel.
26	Radial accelerometer
27	28v battery monitor
28	12v battery monitor

VEHICLE CHECKOUT

Some very severe interference problems were encountered during checkout of the Javelin payload. Because of the severity of these interferences, attention is given here to their cause and effect. The complete experiment including telemetry antennas, whip, and telescoping antennas were covered by the payload heat shield (see Figure 18) because of the exceptionally high velocity achieved by the Javelin rocket during ascent and because of limited space. After the vehicle leaves the dense portions of the atmosphere, this heat shield is ejected and the payload telescoping and whip antennas erect. This physically requires that the telemetry antennas be mounted on the side panels of the instrument rack as shown in Figure 18. This mounting configuration appeared to yield satisfactory antenna patterns, but the unshielded wiring configuration and some experiment configurations created serious telemetry interference problems. The numerous joints in the panels appear to have caused some nonlinearity and there was considerable mixing of the two telemetry frequencies. The difference frequency of the two transmitters (8.8 Mhz) was within the sensitivity range of several of the experiments. Most of the interference problems were eliminated through the use of RF filters, but the resulting difference frequency made the antenna current monitor for the electron temperature probe completely inoperative; hence, this part of the experiment was not included within the payload.

FLIGHT RESULTS

The Javelin rocket (19.191) was launched from NASA/Wallops Island Station, Wallops Island, Virginia, 28 June 1966, at 1623 Zulu time (1233 local time).

Two ground receiving stations were used in connection with the pulse-phase experiment. The first, at Wallops Island, was located approximately five miles from the launcher. The second was located down range at the

NASA facility at Coopers Island, Bermuda. Data from the standing wave impedance probe and electron temperature probe were carried by standard FM/FM telemetry and were recorded at both sites.

At the time of launch, all experiments operated normally and continued to do so until the rocket fourth stage ignition at T + 63 sec. At that time, the 11.5-Mhz transmitter failed and remained inoperative for the remainder of the flight. All other equipment associated with the pulse-phase experiment functioned normally throughout the flight and usable signals were received at both ground stations. No useful data were collected from the pulse-phase experiment because of the failure of the 11.5-Mhz transmitter.

Quick look consideration of telemetry records of the standing wave impedance probe and the electron temperature probe indicated that normal operation occurred throughout the flight and useful data resulted from those experiments. Extensive data reduction and analysis has not been accomplished to date, however, since it is of low priority because of failure to obtain the prime objectives of the experiment.

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APPENDIXES

APPENDIX A

[illegible] PROBE EXPERIMENT INFORMATION AND CALIBRATION DATA

I. GENERAL INFORMATION

Vehicle Code No.	OV2-3	
Electronics Box Code No.	TL-.3-.6-AP-83	
Experiment Type	Unbalanced tapped line	
Experiment Frequencies	.3 Mhz	.6 Mhz
Corresponding Peak Voltages	1.02	4.28
Line Z_o *	49.3	48.1
Tuned Antenna Impedance *	61+j200	59+j200
Antenna Shunt Capacitance *	23 pf	
Antenna Impedance Table No. *	11	
R.F. Cable Information		

A. Type RG-188

B. Lengths Internal to Experiment Box 8"

C. Lengths External to Experiment Box 41 3/4"

D. Total Lengths 49 3/4"

II. CALIBRATION INFORMATION

A. Laboratory Checkout

1. Persons Responsible Hyatt, Green
2. Date Aug 27, 1965
3. Form of Calibration Data Tabular
4. Present Data Location UARL Labs
5. Electronics Box Weight 3 lb. 4 oz.
6. Current Drain 115 ma Voltage 28.0

B. Field Checkout - Location Cape Kennedy

1. Persons Responsible J. Hyatt
2. Date 5 Nov 1965
3. Form of Calibration Data Mag. Tape
4. Present Data Location ARCRL

* Measurements are for 1/2 dipole element

(Supercedes Form No. 100)

Upper Air Research
Form No. 100A
Date Aug 1965

III. LINE CALIBRATION INFORMATION

A. Simulated Telemetry Load Open

B. Calibration Box

1. No. 1 For .3 Mhz

2. No. 1 For .6 Mhz

C. RF Voltage Level at Antenna Jacks

1. ________ P.P. at ________ Mhz

2. ________ P.P. at ________ Mhz

IV. CIRCUIT BOARDS

NAME	MODEL AND SERIAL NO.
Tapped line	TL-.5-114
.3 Mhz Osc.	0-3-2
Osc. Switch	S-2-4
Switch driver	D-1-10
Freq. Switch	FS-1-1
-6 V regulator	VR-1-1
.6 Mhz Osc.	0-3-3

Comments:

VI TAPPED LINE CALIBRATION

Frequency .3 MHz

Resistance 0 / Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1	2.07	1.39	.85	.32	1.73	2.09	2.22	2.29	2.37	2.40	2.44
2	3.59	2.94	2.36	1.74	.99	1.51	1.71	1.82	1.94	2.00	2.07
3	4.23	3.70	3.18	2.60	.27	.81	1.01	1.14	2.26	1.33	1.40
4	4.17	3.92	3.59	3.17	.38	0.00	.05	.14	.23	.29	.36
5	1.21	1.61	1.85	2.01	1.89	1.72	1.66	1.62	1.58	1.55	1.52
6	.38	.01	.26	.63	2.05	2.17	2.21	2.23	2.25	2.26	2.27

Resistance 0 / Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1	1.91	1.23	.69	.19	1.81	2.14	2.26	2.33	2.39	2.42	2.46
2	3.19	2.52	1.93	1.31	1.25	1.74	1.91	2.02	2.12	2.17	2.23
3											
4											
5											
6											

Resistance / Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1											
2											
3											
4											
5											
6											

Record Reactance Values:

Reactance	1	2	3	4	5	6	7	8	9	10	11
Value	+j100	+j75	+j50	+j25	-j25	-j50	-j75	-j100	-j150	-j200	-j300

	Open	Short	50 Ω
1.	2.45	.03	1.31
2.	2.14	1.16	1.31
3.	1.51	2.02	1.28
4.	.47	2.70	1.26
5.	1.44	2.06	1.27
6.	2.23	.94	1.33
7.	2.47	0.00	1.37
8.	2.34	.75	1.36

Upper Air Research
Form No. 100A
Date Aug. 27, 1965

VI TAPPED LINE CALIBRATION

Frequency .3 Mhz

Reactance	1	2	3	4	5	6	7	8	9	10	11
Resistance Tap Point Voltages / 10: 1	1.67	1.18	.82	.50	1.68	2.07	2.19	2.27	2.34	2.38	2.42
2	2.79	2.30	1.89	1.44	.97	1.50	1.69	1.81	1.92	1.98	2.05
3	3.26	2.87	2.50	2.10	.28	.80	1.00	1.13	1.25	1.32	1.39
4	3.19	3.01	2.81	2.55	.37	.01	.06	.14	.23	.29	.35
5	1.03	1.31	1.50	1.65	1.83	1.70	1.64	1.60	1.56	1.54	1.51
6	.59	.45	.52	.70	1.99	2.14	2.19	2.21	2.23	2.24	2.25

Reactance	1	2	3	4	5	6	7	8	9	10	11
Resistance Tap Point Voltages / 10: 1	1.57	1.11	.77	.50	1.76	2.11	2.23	2.30	2.37	2.41	2.44
2	2.49	1.99	1.57	1.14	1.22	1.71	1.89	2.00	2.09	2.15	2.21
3											
4											
5											
6											

Reactance	1	2	3	4	5	6	7	8	9	10	11
Resistance Tap Point Voltages: 1											
2											
3											
4											
5											
6											

Record Reactance Values:

Reactance	1	2	3	4	5	6	7	8	9	10	11
Value	+j100	+j75	+j50	+j25	-j25	-j50	-j75	-j100	-j150	-j200	-j300

VI TAPPED LINE CALIBRATION

Frequency [illegible] Mhz

Resistance 20 — Tap Point Voltages / Reactance	1	2	3	4	5	6	7	8	9	10	11
1	.73	1.24	1.02	.84	1.64	2.04	2.17	2.25	2.33	2.37	2.41
2	1.07	1.93	1.64	1.34	.98	1.48	1.67	1.80	1.91	1.98	2.04
3	1.49	2.29	2.03	1.76	.35	.80	1.00	1.12	1.24	1.31	1.39
4	1.87	2.33	2.20	2.03	.37	.02	.06	.14	.23	.29	.35
5	1.51	1.16	1.30	1.41	1.75	1.67	1.62	1.59	1.55	1.53	1.50
6	1.02	.82	.84	.91	1.93	2.11	2.17	2.19	2.22	2.23	2.24

Resistance 20 — Tap Point Voltages / Reactance	1	2	3	4	5	6	7	8	9	10	11
1	.80	1.22	1.03	.88	1.72	2.09	2.21	2.29	2.36	2.40	2.43
2	.95	1.75	1.47	1.19	1.22	1.69	1.87	1.98	2.08	2.14	2.20
3											
4											
5											
6											

Resistance — Tap Point Voltages / Reactance	1	2	3	4	5	6	7	8	9	10	11
1											
2											
3											
4											
5											
6											

Record Reactance Values:

Reactance	1	2	3	4	5	6	7	8	9	10	11
Value	+j100	+j75	+j50	+j25	−j25	−j50	−j75	−j100	−j150	−j200	−j300

Upper Air Research
Form No. 100A
Date Aug. 27, 1965

VI TAPPED LINE CALIBRATION

Frequency .6 Mhz

Resistance 0

Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1	3.05	2.69	2.10	1.08	1.88	2.53	2.74	2.86	2.95	3.00	3.04
2	3.83	4.17	4.31	4.04	.48	.13	.52	.79	1.06	1.21	1.37
3	1.99	2.70	3.34	3.85	2.59	1.71	1.33	1.08	.84	.70	.55
4	1.33	.71	.08	.72	2.94	3.05	3.03	3.00	2.95	2.92	2.88
5	3.02	3.62	4.08	4.26	1.84	.78	.36	.12	-.01	.03	.14
6	.15	.30	1.03	1.97	3.12	2.87	2.70	2.58	2.45	2.37	2.27

Resistance 0

Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1	2.85	2.44	1.82	.79	2.13	.71	2.88	2.97	3.04	3.07	3.09
2	3.95	4.10	4.01	3.44	.04	.95	1.34	1.59	1.83	1.96	2.09
3											
4											
5											
6											

Resistance

Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1											
2											
3											
4											
5											
6											

Record Reactance Values:

Reactance	1	2	3	4	5	6	7	8	9	10	11
Value	+j100	+j75	+j50	+j25	-j25	-j50	-j75	-j100	-j150	-j200	-j300

	Open	Short	50 Ω
1.	3.08	.02	1.68
2.	1.64	3.19	1.61
3.	.26	3.91	1.58
4.	2.73	1.70	1.73
5.	.41	3.91	1.61
6.	2.07	2.73	1.68
7.	3.12	.12	1.78
8.	2.33	2.37	1.71

VI TAPPED LINE CALIBRATION

Frequency .6 Mhz

Resistance Tap Point Voltages / 10 — Reactance	1	2	3	4	5	6	7	8	9	10	11
1	2.71	2.27	1.71	.99	1.73	2.44	2.70	2.83	2.95	3.01	3.07
2	3.34	3.42	3.30	2.94	.57	.17	.52	.79	1.06	1.22	1.38
3	1.73	2.19	2.52	2.83	2.32	1.65	1.30	.07	.34	.70	.56
4	1.25	.77	.50	.77	2.68	2.95	2.98	2.97	2.95	2.93	2.90
5	2.63	2.95	3.12	3.16	1.66	.76	.37	.14	0.0	.03	.14
6	.36	.47	.93	1.55	2.84	2.77	2.66	2.56	2.46	2.38	2.30

Resistance Tap Point Voltages / 10 — Reactance	1	2	3	4	5	6	7	8	9	10	11
1	2.53	2.06	1.52	.88	1.99	2.62	2.83	2.94	3.04	3.08	3.13
2	3.46	3.34	3.09	2.71	.31	.95	1.33	1.58	1.83	1.97	2.12
3											
4											
5											
6											

Resistance Tap Point Voltages — Reactance	1	2	3	4	5	6	7	8	9	10	11
1											
2											
3											
4											
5											
6											

Record Reactance Values:

Reactance	1	2	3	4	5	6	7	8	9	10	11
Value	+j100	+j75	+j50	+j25	-j25	-j50	-j75	-j100	-j150	-j200	-j300

Upper Air Research
Form No. 100[illegible]
Date Aug. 27, 1965

VI TAPPED LINE CALIBRATION

Frequency .6 Mhz

Resistance 20 Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1	2.55	2.15	1.75	1.28	1.73	2.37	2.63	2.79	2.92	2.98	3.04
2	3.03	3.00	2.87	2.57	.66	.28	.55	.79	1.05	1.21	1.37
3	1.54	1.90	2.17	2.37	2.07	1.56	1.27	1.05	.83	.70	.55
4	1.34	1.05	.95	1.11	2.51	2.83	2.90	2.92	2.92	2.90	2.88
5	2.37	2.57	2.67	2.64	1.49	.74	.37	.16	.02	.04	0.14
6	.63	.75	1.06	1.50	2.60	2.65	2.58	2.51	2.42	2.36	2.28

Resistance 20 Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1	2.44	2.04	1.66	1.28	1.95	2.54	2.77	2.90	3.00	3.06	3.10
2	3.20	3.03	2.79	2.35	.61	1.00	1.33	1.57	1.81	1.96	2.10
3											
4											
5											
6											

Resistance Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1											
2											
3											
4											
5											
6											

Record Reactance Values:

Reactance	1	2	3	4	5	6	7	8	9	10	11
Value	+j100	+j75	+j50	+j25	-j25	-j50	-j75	-j100	-j150	-j200	-j300

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. TL-.3-.6-AR-83 Date July 20, 1965

Line No. TL-.5-114 Operator Paul A. Shaffer

Output Voltage from Generator 1.5 G. Reading

PIN NO. (Numbered from osc end)	FREQ. .3 Mhz		FREQ.		FREQ. .3 Mhz	
		50 Ω		Pin No.		50 Ω
1 SWIP 8	.61	1.54	.	25 .	2.58	1.46
2	.331	1.58	.	26 .	2.40	1.45
3	.169	1.60	.	27 .	2.21	1.44
4	.333	1.61	.	28 .	2.01	1.44
5 SWIP 7	.62	1.65	.	29 SWIP 3	1.81	1.44
6	.90	1.69	.	30 .	1.59	1.45
7	1.18	1.70	.	31 .	1.38	1.46
8	1.44	1.71	.	32 .	1.13	1.48
9 SWIP 6	1.64	1.72	.	33 SWIP 2	.86	1.50
10	1.89	1.72	.	34 .	.57	1.50
11	2.11	1.72	.	35 .	.271	1.50
12	2.30	1.72	.	36 .	.052	1.52
13	2.49	1.71	.	37 .	.311	1.55
14 SWIP 5	2.63	1.71	.	38 SWIP 1	.62	1.59
15	2.77	1.70	.	.	.	.
16	2.88	1.68	.	.	.	.
17	2.93	1.64	.	.	.	.
18	3.00	1.61	.	.	.	.
19	*3.01	1.59	.	.	.	.
20	3.00	1.54	.	.	.	.
21	2.98	1.50	.	.	.	.
22	2.90	1.50	.	.	.	.
23	2.81	1.50	.	.	.	.
24 SWIP 4	2.70	1.48	.	.	.	.

* Maximum or minimum voltage on the line

109-4/65

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. TL-.3-.6-AR-83 Date July 20, 1965

Line No. TL-.5-114 Operator Paul A. Shaffer

Output Voltage from Generator 1.5

PIN NO. (Numbered from osc end)	FREQ. .6 Mhz		FREQ.		FREQ. .6 Mhz	
		50 Ω		Pin No.		50 Ω
1 SWIP 8	1.82	1.59	.	25 .	2.11	1.62
2	1.40	1.59	.	26 .	2.49	1.61
3	.89	1.61	.	27 .	2.72	1.60
4	.374	1.62	.	28 .	2.90	1.59
5 SWIP 7	.321	1.67	.	29* SWIP 3	2.98	1.55
6	.86	1.69	.	30 .	2.91	1.52
–	1.39	1.69	.	31 .	2.79	1.50
8	1.81	1.69	.	32 .	2.54	1.49
9 SWIP 6	2.21	1.68	.	33 SWIP 2	2.22	1.49
10	2.55	1.66	.	34 .	1.82	1.48
11	2.79	1.62	.	35 .	1.41	1.49
12	2.90	1.60	.	36 .	.88	1.50
13	2.91	1.58	.	37 .	.302	1.52
14 SWIP 5	2.86	1.52	.	38 SWIP 1	2.69	1.54
15	2.69	1.51	.	.	.	.
16	2.39	1.50	.	.	.	.
17	2.00	1.50	.	.	.	.
18	2.53	1.50	.	.	.	.
19	1.09	1.52	.	.	.	.
20	.52	1.56	.	.	.	.
21	1.41	1.59	.	.	.	.
22	.66	1.60	.	.	.	.
23	1.21	1.62	.	.	.	.
24 SWIP 4	1.68	1.63	.	.	.	.

* Maximum or minimum voltage on the line

109-4/65

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. TL-.3-.6-AR-83 Date July 19, 1965

Line No. TL-.5-114 Operator Paul A. Shaffer

Calibration Check Freq.	.34 Mhz		.610 Mhz			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	* 5.2-j17 5.4-j17	* 5.3+j19 5.3+j19	* 3.95-j29.5 3.95-j29.5	* 4.15-j33 15-j33	* j j	* j j
Z Short Circuit	* 3.75+j13 3.75+j13	* 3.75+j15 3.[illegible]5+j15 3.85+j15	* 3.8+ j24 3.8+ j24	* 4.3 +j26 4.3 +j26	* j j	* j j
Z_{50} ohm	42.5-j0 * 42.5-j0	49.5-j3 * 49.5-j3	45- j2 * 45- j2	48.5-j4 * 48.5-j4	j * j	j * j
$Z_o = \sqrt{Z_{oc} Z_{sc}}$	43.8 +∠.22° j	49.3 +∠.22° j	43.7∠-.38° j	48.1∠-.7° j	j	j
$\gamma_d = 1/2 \ln \frac{Z_o + Z_{sc}}{Z_o - Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in hz.

110-9/66

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. FL-2-7.2-BS-85 Date Sept 9, 1965

Line No. FL-3-122 Operator Paul A. Shaffer

Calibration Check Freq.	2 Mhz		6.8 Mhz			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	* 14.6+ j159 14.6+ j159	* 14.7+j155 14.7+j155	* 17.5+j415 17.5+j415	* 17.8+j413 17.8+j418	* j j	* j j
Z Short Circuit	* 4.3- j64 4.3- j64	* 4.1-j62.5 4.1-j62.5	* 10-j265 10-j265	* 10- j264 10- j265	* j j	* j j
Z_{50} ohm	50-j1 * 50-j1	49-j4 * 49-j4	49.5-j10* 49.5-j10	50-j9 * 50-j9	j * j	j * j
$Z_o = \sqrt{Z_{oc}Z_{sc}}$	51.1∠-1.38° j	49.9∠-1.55° j	50.6∠-.80° j	50.7∠-.90° j	j	j
$\gamma_d = 1/2 \ln \frac{Z_o+Z_{sc}}{Z_o-Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in Mhz.

110-9/66

ANTENNA MEASUREMENTS

Date Recorded I July 1965

By Rulon K. Linford

Vehicle: Type Satellite

Number OV2-3

Diameter 2' x 2' square

Length 2'

Irregularities See John Hyatt's Notebook of Diagrams

System: Balanced [ ] Unbalanced [X]

Antenna: Type DeHavilland Tape

Length 29' 6" (from top of antenna mount)

Detailed description (Material, wire diameter, etc.):

Beryllium copper tape

Mounting: Type DeHavilland 30' tape

Standard [X] Not Standard [ ]

Antenna Cable Length 12"

Position: Distance from Nose to Antenna center ---------------

If not centered, explain Centered between two edges 7" from the top to the antenna center.

Other necessary dimensions Metal cover placed over the antenna mount. See Drawing No. BME 52-305

Experiment: SWIP

Frequencies of operation: 300 khz 600 khz

112-8/65

Impedance Data

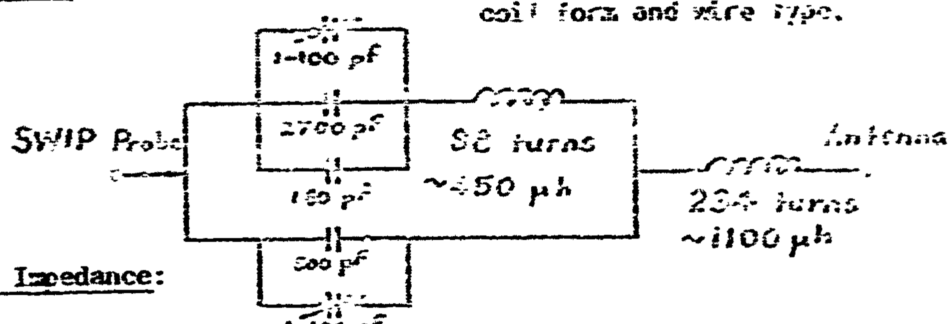
Original data recorded in Notebook 234 (No.) Rulon K. Linford

Page 5 Date 12 July 1965

Frequency in Mhz	Corrected Impedance (Ant. shunt capacitance included)
.1	—— -j 11,230
.2	—— -j 5,360
.3	—— -j 3,580
.4	—— -j 2,690
.5	<13 -j 2,144
.6	<13 -j 1,725
.7	<13 -j 1,530
.8	<15 -j 1,345
.9	<13 -j 1,193
1.0	<11 -j 1,073
1.5	< 7.7 -j 715
2.0	≤5.6 -j 527
3.0	4.8 -j 323
4.0	4.16-j 236
5.0	4.5 -j 165

Shunt Capacitance: 23 pf.

Matching Network: Circuit and Values See Hugo Johansson's Notebook for coil form and wire type.



Final Tuned Impedance:

Frequency	Impedance
300 khz	61+j200
600 khz	59+j200

Approved by

112a-8/65

Imp. Trace Data.

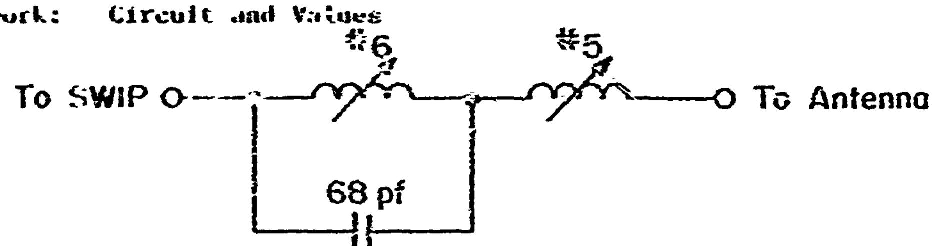
Original data recorded in Notebook 234 No. — Eulon K. Linford, Name

Page 34 Date Jan. 15, 1966

Frequency in Mc	Corrected Impedance (Ant. shunt capacitance included)
1	1.1-j1230
1.5	1.7-j793
2	2.2-j578
3	3.3-j369
4	5.5-j256
5	10.9-j172
6	16.2-j105
7	30.1-j32.5
7.2	32.4-j20
8	55.8+j47.7
9	113+j151
10	276+j277

Shunt Capacitance: 33.4 pf.

Matching Network: Circuit and Values



Final Tuned Impedance:

Frequency	Impedance	Impedance
	Network T	Network F
2.0	11.8+j50	12.5+j49
7.2	38.5+j50	47.0+j50

112a-7/66

Upper Air Research
Form No. 100A
Date ______

APPENDIX B

IMPEDANCE PROBE EXPERIMENT INFORMATION AND CALIBRATION DATA

I. GENERAL INFORMATION

Vehicle Code No.	OV3-2	
Electronics Box Code No.	TL-2-7.2-BS-85	
Experiment Type	Balanced	
Experiment Frequencies	2 Mhz	7.2 Mhz
Corresponding Mode Voltages	0.45	2.71
Line Z_o *		
Tuned Antenna Impedance *		
Antenna Shunt Capacitance *		
Antenna Impedance Table No. *		
R.F. Cable Information		

A. Type RG-188
B. Lengths Internal to Experiment Box 6"
C. Lengths External to Experiment Box 11 1/4"
D. Total Length 17 1/4"

II. CALIBRATION INFORMATION

A. Laboratory Checkout
1. Persons Responsible Del Green
2. Date ______
3. Form of Calibration Data Data sheet
4. Present Data Location UARL
5. Electronics Box Weight 3 lbs. 9 oz.
6. Current Drain 160 ma Voltage 28 v

B. Field Checkout - Location ______
1. Persons Responsible ______
2. Date ______
3. Form of Calibration Data ______
4. Present Data Location ______

* Measurements are for 1/2 dipole element

(Supercedes Form No. 100)

Upper Air Research
Form No. 10CA
Date ____________

III. LINE CALIBRATION INFORMATION

A. Simulated Telemetry Load ____________

B. Calibration Box

1. No. 3 Mhz #1 For 2 Mhz Mhz
2. No. 7.2 Mhz #2 For 7.2 Mhz Mhz

C. RF Voltage Level at Antenna Jacks

1. 2.6 P.P. at 2 Mhz
2. 2.6 P.P. at 7.2 Mhz

IV. CIRCUIT BOARDS

NAME	MODEL AND SERIAL NO.
-6 v regulator	VR-1-3
SW. driver	D-1-12
Osc. 7.2 Mhz	O-1-8
Diode Sw.	S-3-1
Osc. 2 Mhz	O-3-12
Freq. Switch	FS-1-3
Fixed Line	FL-3-122
Tapped Line	TL-3-119

Comments:

Upper Air Research
Form No. 100A
Date Dec. 11, 1965

VI TAPPED LINE CALIBRATION

Frequency 2 Mhz Box #1

Resistance 5.6

Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1	2.36	1.39	.95	.52	.70	4.01	4.07	3.96	3.91	3.78	3.77
2	0.74	0.26	.55	1.14	1.98	3.11	3.31	2.96	2.84	2.58	2.57
3	1.14	2.01	2.37	2.80	3.26	1.18	1.49	0.96	.80	.51	.59
4	2.93	3.34	3.45	3.52	3.47	.77	.47	1.00	1.15	1.44	1.46
5	3.85	3.71	3.53	3.22	2.66	2.80	2.51	2.98	3.09	3.27	3.32
6	3.73	3.13	2.76	2.21	1.36	3.85	3.71	3.94	4.00	4.08	4.09

Resistance 13

Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1	2.34	1.44	1.08	.80	.94	3.98	4.02	3.94	3.90	3.79	3.77
2	.77	.42	.66	1.15	1.84	3.08	3.25	2.94	2.83	2.59	2.57
3	1.13	1.92	2.24	2.58	2.94	1.18	1.47	.96	.81	.52	.51
4	2.91	3.22	3.28	3.28	3.16	.79	.52	1.01	1.16	1.45	1.47
5	3.84	3.58	3.38	3.04	2.48	2.79	2.51	2.97	3.09	3.30	3.32
6	3.70	3.03	2.65	2.12	1.40	3.82	3.65	3.92	3.99	4.08	4.09

Resistance 27

Tap Point Voltages \ Reactance	1	2	3	4	5	6	7	8	9	10	11
1	2.33	1.54	1.30	1.16	1.29	3.90	3.90	3.88	3.87	3.79	3.77
2	.82	.62	.83	1.20	1.73	3.02	3.14	2.91	2.81	2.59	2.57
3	1.10	1.79	2.04	2.29	2.53	1.16	1.43	.96	.81	.53	.51
4	2.82	3.00	3.00	2.94	2.76	.82	.59	1.02	1.17	1.45	1.47
5	3.74	3.38	3.15	2.81	2.32	2.75	2.47	2.95	3.08	3.30	3.32
6	3.61	2.90	2.54	2.10	1.57	3.75	3.56	3.88	3.96	4.07	4.09

Record Reactance Values:

Reactance	1	2	3	4	5	6	7	8	9	10	11
Value	+j200	+j100	+j75	+j50	+j25	-j25	-j50	-j75	-j100	-j200	-j300

VI TAPPED LINE CALIBRATION

Frequency 7.2 Mhz

Resistance 5.6 — Tap Point Voltages / Reactance	1	2	3	4	5	6	7	8	9	10	11
1	3.42	3.23	2.92	2.25	1.66	1.15	2.46	3.64	4.27	4.32	4.26
2	1.53	1.74	2.00	2.43	2.61	3.10	2.95	2.40	1.49	1.25	1.12
3	2.58	2.45	2.11	1.55	1.30	1.85	3.35	4.24	4.32	4.17	3.99
4	3.39	3.45	3.40	3.22	2.97	2.36	1.23	1.61	2.47	2.77	2.98
5	.82	1.02	1.20	1.76	2.29	2.95	3.44	3.21	2.31	1.88	1.63
6	3.48	3.33	3.14	2.62	2.03	.98	1.32	2:63	3.58	3.77	3.82

Resistance 10 — Tap Point Voltages / Reactance	1	2	3	4	5	6	7	8	9	10	11
1	3.34	3.16	2.87	2.25	1.65	1.25	2.39	3.54	4.19	4.27	4.21
2	1.53	1.73	1.99	2.50	2.74	3.01	2.82	2.32	1.52	1.29	1.14
3	2.52	2.39	2.06	1.47	1.30	1.90	3.25	4.05	4.21	4.08	3.96
4	3.35	3.39	3.31	3.26	2.85	2.29	1.30	1.64	2.45	2.77	2.93
5	.69	.95	1.19	1.78	2.22	2.86	3.26	3.05	2.25	1.87	1.59
6	3.44	3.30	3.07	2.66	1.95	1.03	1.36	2.53	3.49	3.71	3.76

Resistance 25 — Tap Point Voltages / Reactance	1	2	3	4	5	6	7	8	9	10	11
1	3.29	3.18	3.89	2.38	2.00	1.76	2.41	3.24	3.97	4.15	4.14
2	1.54	1.79	1.99	2.29	2.48	2.64	2.42	2.11	1.52	1.32	1.18
3	2.50	2.39	2.10	1.73	1.67	1.96	2.81	3.58	3.98	3.98	3.87
4	3.30	3.39	3.27	3.06	2.80	2.34	1.66	1.92	2.47	2.80	2.97
5	.86	1.04	1.22	1.65	2.00	2.37	2.61	2.63	2.12	1.83	1.59
6	3.36	3.23	2.97	2.42	1.96	1.36	1.57	2.30	3.28	3.53	3.69

Record Reactance Values:

Reactance	1	2	3	4	5	6	7	8	9	10	11
Value	L5	L4	L3	L2	L1	0	C1	C2	C3	C4	C5

ANTENNA MEASUREMENTS

Date Recorded Jan. 15, 1966

By Rulon K. Linford

Vehicle: Type Blue Scout Satellite

Number OV3-2

Diameter 28"

Length 28 1/4"

Irregularities Two pairs of booms in the same horizontal plane and at 45° angles from SWIP antennas.

System: Balanced [X] Unbalanced [ ]

Antenna: Type De Havilland

Length 30 ft

Detailed Description (Material, wire diameter, etc.):

Standard beryllium-copper strip

Mounting: Type De Havilland antenna

Standard [X] Not Standard [ ]

Position: Distance from Nose to Antenna Center 14 1/8"

If not centered, explain

Antenna Cable Length

Other necessary dimensions

Experiment: SWIP

Frequencies of Operation: 2 Mhz and 7.2 Mhz

Approved By

112-7/66

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. TL-2-7.2-[illegible]-85 Date Sept 10, 1965

Line No. TL-3-119 Operator Paul A. Shaffer

Output Voltage from Generator 1.5

PIN NO. (Numbered from-ese-end) ant.	FREQ. 2 Mhz		FREQ. 7.2 Mhz		FREQ.	
		50 Ω		50 Ω		50 Ω
1 SWIP 6	1.26	1.50	.43[illegible]	1.52	.	.
2	1.50	1.50	.89	1.46	.	.
3	1.76	1.49	1.69	1.45	.	.
4	2.09	1.48	2.29	1.44	.	.
5 SWIP 5,7	2.21	1.48	2.49	1.44	.	.
6	2.40	1.47	2.30	1.45	.	.
7	2.58	1.46	1.77	1.44	.	.
8	2.69	1.45	305	1.44	.	.
9	2.79	1.45	.269	1.44	.	.
10 SWIP 4	2.82	1.45	1.12	1.44	.	.
11	*2.84	1.45	1.99	1.46	.	.
12	2.82	1.45	2.51	1.47	.	.
13	2.79	1.44	*2.70	1.50	.	.
14	2.69	1.44	2.51	1.50	.	.
15 SWIP 3	2.58	1.44	1.91	1.47	.	.
16	2.41	1.44	1.06	1.42	.	.
17	2.21	1.44	.149	1.36	.	.
18	2.00	1.44	.96	1.30	.	.
19	1.76	1.44	1.78	1.29	.	.
20 SWIP 2	1.50	1.44	2.30	1.29	.	.
21	1.23	1.44	2.49	1.30	.	.
22	.94	1.43	2.22	1.32	.	.
23	.64	1.42	1.60	1.32	.	.
24 SWIP 1	.331	1.41	.79	1.33	.	.

* Maximum or minimum voltage on the line

[illegible]

ASSIGNED TO PROBE NO. TL-2-7.2-BS-85 **Date** Sept 10, 1965

Line No. FL-3-122 **Operator** Paul A. Shaffer

Output Voltage from Generator 1.5 v

PIN NO. (Numbered from osc end)	FREQ. 2 Mhz		FREQ. 7.2 Mhz		FREQ.	
		50 Ω		50 Ω		50 Ω
1	1.26	1.52	.51	1.52	.	.
2	1.50	1.52	.74	1.50	.	.
3	1.79	1.51	1.61	1.48	.	.
4	2.02	1.51	2.28	1.47	.	.
5	2.26	1.50	2.53	1.46	.	.
6	2.45	1.50	2.40	1.44	.	.
[illegible]	2.61	1.50	1.86	1.43	.	.
8	2.73	1.49	1.01	1.44	.	.
9	2.82	1.49	.248	1.45	.	.
10	2.90	1.48	1.10	1.48	.	.
11	*2.91	1.48	1.98	1.50	.	.
12	2.90	1.47	2.55	1.51	.	.
13	2.82	1.47	*2.75	1.50	.	.
14	2.73	1.47	2.55	1.49	.	.
15	2.61	1.46	1.96	1.46	.	.
16	2.45	1.46	1.09	1.42	.	.
17	2.25	1.46	.139	1.37	.	.
18	2.01	1.46	.98	1.34	.	.
19	1.78	1.46	1.81	1.34	.	.
20	1.50	1.45	2.38	1.32	.	.
21	1.22	1.45	2.52	1.34	.	.
22	.92	1.45	2.28	1.34	.	.
23	.59	1.45	1.59	1.35	.	.
24	.281	1.45	.74	1.36	.	.

* Maximum or minimum voltage on the line

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. TL-2-7.2-8S-85 Date Sept 10, 1965

Line No. TL-3-119 Operator Paul A. Shaffer

Calibration Check Freq.	2 Mhz		6.8 Mhz			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	* 15.9+j150 15.9+j150	* 15.9+j150 15.9 j 151	* 16.1+j338 16.1+j338	* 16.3+ j350 16.3+ j350	* j j	* j j
Z Short Circuit	* 4.9-j61 4.9-j60	* 4.9-j60 4.9-j60	* 12.3-j295 12.3-j294	* 11.6-j285 11.6-j285	* j j	* j j
Z_{50} ohm	* 48.5+j1 48.5+j1	* 48.5+j1 48.5+j1	* 49+j6 49+j6	* 47.5-j6 47.0-j6	* j j	* j j
$Z_o = \sqrt{Z_{oc} Z_{sc}}$	48.7∠-1.43 j	48.5∠-1.31 j	48.6∠-1.02 j	48.45∠1.05 j	j	j
$\gamma_d = 1/2 \ln \frac{Z_o + Z_{sc}}{Z_o - Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in hz.

Upper Air Research
Form No. 100A
Date Nov. 27, 1965

APPENDIX C

IMPEDANCE PROBE EXPERIMENT INFORMATION
AND CALIBRATION DATA

I. GENERAL INFORMATION

Vehicle Code No.	Javelin 19.191	
Electronics Box Code No.	CL-3.0-7.2-JA-75	
Experiment Type	Balanced	
Experiment Frequencies	3.0 Mhz	7.2 Mhz
Corresponding Mode Voltages	0.55 V	3.5 V
Line Z_o *		
Tuned Antenna Impedance *		
Antenna Shunt Capacitance *		
Antenna Impedance Table No. *		
R.F. Cable Information		

A. Type RG-188
B. Lengths Internal to Experiment Box 5 1/2"
C. Lengths External to Experiment Box 43"
D. Total Lengths 48 1/2"

II. CALIBRATION INFORMATION

A. Laboratory Checkout
1. Persons Responsible Del Green
2. Date 11-27-65
3. Form of Calibration Data Visicorder
4. Present Data Location UARL
5. Electronics Box Weight 3 lb. 13 oz.
6. Current Drain 260 ma Voltage 28 V

B. Field Checkout - Location ________
1. Persons Responsible ________
2. Date ________
3. Form of Calibration Data ________
4. Present Data Location ________

* Measurements are for 1/2 dipole element

(Supercedes Form No. 100)

Upper Air Research 73
Form No. 100A
Date 11-27-65

III. LINE CALIBRATION INFORMATION

A. Simulated Telemetry Load ______________

B. Calibration Box

1. No. 1 For 3 Mhz Mhz

2. No. 2 For 7.2 Mhz Mhz

C. RF Voltage Level at Antenna Jacks

1. 2.3 P.P. at 3 Mhz

2. 3.0 P.P. at 7.2 Mhz

IV. CIRCUIT BOARDS

NAME	MODEL AND SERIAL NO.
Fixed line	FL-5-101
Comm. line	CL-5-102
Sw. driver	D-1-4
Osc. 3 Mhz	0-1-7
Osc. Sw.	S-1-4
Osc. 7.2 Mhz	0-1-10

Comments:

Upper Air Research
Form No. 100A
Date 11-27-65

V. VISICORDER RECORD, CORRUGATED LINES

Attach RF Cables for Following Test:

IMPEDANCE	FREQ. 3Mhz	IMPEDANCE	FREQ. 3 Mhz	IMPEDANCE	FREQ. 7.2 Mhz	IMPEDANCE	FREQ. 7.2 Mhz
	Cal. Box #1				Cal. Box #2		
Open		50 -J75		25 + L5		100 + 0	
Short		-J100		+ L4		+C1	
50 ohms		-J150		+ L3		+C2	
39 + J200		-J200		+ L2		+C3	
+ J150		-J300		+ L1		+C4	
+ J100		-J500		0		+C5	
+ J75		-J750		+ C1			
+ J50		-J1000		+ C2			
+ J25		75 +J200		+ C3			
- J25		+J150		+ C4			
- J50		+J100		+ C5			
- J75		+J75		50 + L5			
- J100		+J50		+ L4			
- J150		+J25		+ L3			
- J200		-J25		+ L2			
- J300		-J50		+ L1			
- J500		-J75		0			
- J750		-J100		+ C1			
- J1000		-J150		+ C2			
50 + J200		-J200		+ C3			
+ J150		-J300		+ C4			
+ J100		-J500		+ C5			
+ J75		-J750		100 + L5			
+ J50		-J1000		+ L4			
+ J25				+ L3			
- J25				+ L2			
- J50				+ L1			

Comments:

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. CL-3-7.2-JA-75 Date May 14, 1965

Line No. CL-5-102 Operator Paul A. Schaffer

Output Voltage from Generator 1.07

PIN NO. (Numbered from osc end)	FREQ. 12 Mhz		FREQ.		FREQ.	
		50 Ω		50 Ω		50 Ω
1	1.01	1.07				
2	.437	1.04				
3	.310	1.00				
4	.91	.98				
5	1.38	.98				
6	1.56	1.00				
7	1.50	1.01				
8	1.25	1.02				
9	.75	1.02				
10	.148	1.01				
11	.62	1.01				
12	1.20	1.02				
13	1.54	1.03				
* 14 *	1.68	1.04				
15	1.54	1.02				
16	1.21	1.00				
17	.65	.97				
18	.070	.94				
19	.71	.92				
20	1.24	.92				
21	1.50	.94				
22	1.57	.95				
23	1.41	.96				
24	1.00	.96				

* Maximum or minimum voltage on the line

TRANSMISSION LINE RF MEASUREMENTS

ASSIGNED TO PROBE NO. CL-3.0 - 7.2 JA - 75 Date April 7, 1965

Line No. CL-5*102 Operator Paul A. Shaffer

Output Voltage from Generator 1.5

PIN NO. (Numbered from one end)	FREQ. 3 Mhz Short	50 Ω	FREQ. 7.2 Mhz Short	50 Ω	FREQ.	50 Ω
1	1.70	1.45	.76	1.40	.	.
2	1.91	1.44	1.22	1.38	.	.
3	2.10	1.43	1.73	1.36	.	.
4	2.30	1.43	2.16	1.34	.	.
5	2.46	1.43	2.43	1.34	.	.
6	2.59	1.42	2.53	1.34	.	.
7	2.69	1.42	2.50	1.34	.	.
8	2.77	1.42	2.31	1.35	.	.
9	2.80	1.42	1.97	1.34	.	.
10 *	2.82	1.42	1.48	1.33	.	.
11	2.80	1.42	.970	1.31	.	.
12	2.78	1.42	.340	1.30	.	.
13	2.70	1.42	.338	1.30	.	.
14	2.59	1.41	.960	1.29	.	.
15	2.48	1.41	1.48	1.30	.	.
16	2.30	1.41	2.00	1.30	.	.
17	2.11	1.41	2.37	1.31	.	.
18	1.90	1.40	2.59	1.33	.	.
19	1.67	1.40	* 2.67	1.34	.	.
20	1.40	1.39	2.59	1.35	.	.
21	1.18	1.39	2.37	1.36	.	.
22	.92	1.38	2.00	1.35	.	.
23	.64	1.37	1.50	1.34	.	.
24	.372	1.36	.920	1.32	.	.

* Maximum or minimum voltage on the line

109-4/65

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. CL-3.0-7.2-JA-75 Date 4-10-65

Line No. CL-5-102 Operator Paul A. Shaffer

Calibration Check Freq.	3Mhz		7.2 Mhz			
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	* 6.5+j154 6.5+j154	* 6.6+j155 6.6+j155	* 14+j525 14+j525	* 13.7+j520 13.7+j520	* j j	* j j
Z Short Circuit	* 4.05-j143 4.05-j142	* 4.1-j143 4.1-j143	* 5.5+j229 5.5 j229	* 5.39+j220 5.39 j220	* j j	* j j
Z_{50} ohm	* 48.5-j 4 48.5-j 4	* 49- j3 49-j3	* 48.5+j3 48.5+j4	* 47.5+j1 47. +j1	* j j	* j j
$Z_o = \sqrt{Z_{oc} Z_{sc}}$	49.65 j∠-1.19°	49.85∠-1.13° j	49.0 j∠.54°	47.8 j∠.40°	j	j
$\gamma_d = 1/2 \ln \frac{Z_o + Z_{sc}}{Z_o - Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in Mhz.

TRANSMISSION LINE BRIDGE MEASUREMENTS

Assigned to Probe No. CI-3-7 2-75　　　Date June 11, 1965

Line No. CI-5-102　　　Operator Paul A. Sheffer

Calibration Check Freq.	12.6 Mhz					
End Measured	OSC End	Ant End	OSC End	Ant End	OSC End	Ant End
Z Open Circuit	* 18.4-j984 18.4-j985	* 18.4-j978 18.4-j978	* j j	* j j	* j j	* j j
Z Short Circuit	* 8.3+j405 8.3+j405	* 8.2+j399 8.2+j398	* j j	* j j	* j j	* j j
Z_{50} ohm	* 51.5-j15 51.5-j16	* 50.5-j9 50.5-j11	* j j	* j j	* j j	* j j
$Z_o = \sqrt{Z_{oc} Z_{sc}}$	51.6 ∠-.6 j	51.05 ∠-.58 j	j	j	j	j
$\gamma_d = 1/2 \ln \frac{Z_o + Z_{sc}}{Z_o - Z_{sc}}$	j	j	j	j	j	j

* Divide the reactive component of all impedances by the calibration check freq. in hz.

ANTENNA MEASUREMENTS

Date Recorded 23 November 1963

By Rulon K. Linford

Vehicle: Type Javelin

Number AC 19.191

Diameter 17 1/2 inches

Length 101 in.

Irregularities Nose skin ejected exposing rack.

System: Balanced [X] Unbalanced [ ]

Antenna: Type Ralph telescoping

Length 10 ft. 1 3/4 in.

Detailed Description (Material, wire diameter, etc.):

Standard

Mounting: Type Ralph telescoping (no gas cartridge)

Standard [X] Not Standard [ ]

Position: Distance from Nose to Antenna Center second deck from ~~If not standard, describe~~ top. Mounted on deck of rack rather than the skin. Base also mounted on about a 10° wedge. See Javelin diagram.

Antenna Cable Length 5 1/2 inches

Other necessary dimensions

Experiment: SWIP

Frequencies of Operation: 3.0 Mhz and 7.2 Mhz

Approved By

112-7/66

Impedance Data.

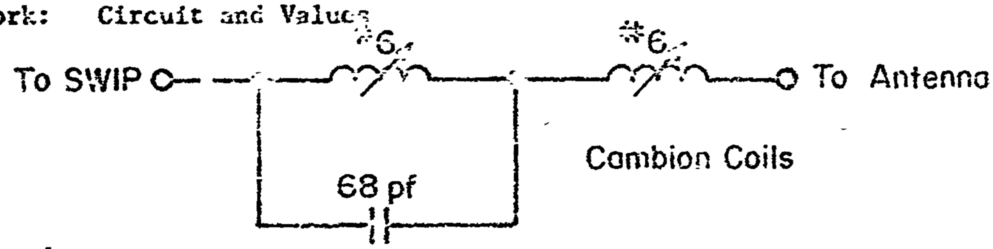
Oridinal data recorded in Notebook 234 Rulon K. Linford
No. Name

Page 22 **Date** 20 November 1965

Frequency in Mhz	Corrected Impedance (Ant. shunt capacitance included)
1	10 -j 2470
2	3.9 -j 1240
3	3.3 -j 825
4	2.5 -j 588
5	2.3 -j 485
6	2.3 -j 395
7	2.3 -j 334
8	2.2 -j 283
9	2.3 -j 243
10	3.4 -j 215
11	3.7 -j 187
12	4.5 -j 165
13	4.5 -j 165
14	-- -j 122
15	5.0 -j 113
7.2	2.3 -j 323

Shunt Capacitance: 28.2 **pf.**

Matching Network: Circuit and Values



Final Tuned Impedance:

Frequency	Impedance	Impedance
---	Network #1	Network No. 2
3	22 +j 50	21.5 +j 50
7.2	30.5 + j 50	29 +j 50

18 April 1966

JAVELIN

Step Electron Temperature Probe

Voltage Calibration - Unit No. 100

Step	Voltage Out
1	+2.58 v
2	+2.10 v
3	+1.55 v
4	+1.05 v
5	+ .53 v
6	+ .04 v
7	- .49 v
8	- .97 v

18 April 1966

Fine Frequency Calibration - JAVELIN

RF Input .5v Peak to Peak

Frequency	Output Volts (dc)		Frequency	Output Volts (dc)	
.1 MHz	.070		5.2 MHz	.065	
.2	.224		5.3	.179	
.3	.420		5.4	.303	
.4	.554		5.5	.412	
.5	.568	peak	5.6	.459	peak
.6	.468		5.7	.431	
.7	.300		5.8	.329	
.8	.130		5.9	.216	
.9	.019	valley	6.0	.097	valley,
1.0	.021		6.1	.019	6.06MHz
1.1	.133		6.2	.072	.017v
1.2	.294		6.3	.187	
1.3	.447		6.4	.307	
1.4	.539	peak,	6.5	.408	
1.5	.527	1.44MHz	6.6	.450	peak,
1.6	.425	.544v	6.7	.432	6.62MHz
1.7	.276		6.8	.356	.452v
1.8	.115		6.9	.247	
1.9	.012	valley,	7.0	.134	
2.0	.031	1.93MHz	7.1	.032	valley,
2.1	.135	.007v	7.2	.019	7.18MHz
2.2	.302		7.3	.067	.017v
2.3	.473		7.4	.152	
2.4	.510		7.5	.245	
2.5	.496		7.6	.328	peak
2.6	.399		7.7	.423	
2.7	.254		7.8	.267	
2.8	.106		7.9	.191	
2.9	.020	valley,	8.0	.108	
3.0	.037	2.94MHz	8.1	.038	valley,
3.1	.147	.013v	8.2	.020	8.19MHz
3.2	.294		8.3	.062	.019v
3.3	.425		8.4	.141	
3.4	.492	peak,	8.5	.224	
3.6	.392	3.43MHz	8.6	.297	
3.7	.264	.499v	8.7	.330	peak
3.8	.130		8.8	.321	
3.9	.036	valley,	8.9	.267	
4.0	.022	3.96MHz	9.0	.202	
4.1	.101	.016v	9.1	.113	
4.2	.228		9.2	.038	valley,
4.3	.359		9.3	.034	9.25MHz
4.4	.451		9.4	.104	.027v
4.5	.489	peak	9.5	.194	
4.6	.462		9.6	.277	
4.7	.382		9.7	.315	peak,
4.8	.277		9.8	.307	9.72MHz
4.9	.158		9.9	.263	.318v
5.0	.060		10.0	.197	
5.1	.019	valley			

18 April 1966

Coarse Frequency Calibration - JAVELIN Temperature Probe

RF Amplitude = .3v Peak to Peak

Frequency	Output Volts (dc)
.1 MHz	.732
.5	.707
1.0	.666
1.5	.625
2.0	.556
2.5	.500
3.0	.437
3.5	.387
4.0	.329
4.5	.287
5.0	.252
5.5	.217
6.0	.184
6.5	.147
7.0	.128
7.5	.100
8.0	.083
8.5	.062
9.0	.049
9.5	.037
10.0	.024

18 April 1966

JAVELIN - Unit No. 100

RF Voltage Calibration

A-C Out / Frequency	.02	.04	.06	.08	.1	.12	.14	.16	.18	.20	.22	.24	.26	.28
.1 MHz	0	0	.03	.23	.37	.59	.83	1.08	1.34	1.63	1.91	2.19	2.48	2.72
.25	0	.05	.41	.81	1.07	1.44	1.68	2.78	2.65	2.96	3.22	3.42	3.57	3.69
.50	0	.11	.56	1.04	1.34	1.80	2.26	2.69	3.04	3.30	3.49	3.63	3.75	3.82
.75	0	.14	.61	1.11	1.43	1.91	2.40	2.80	3.10	3.36	3.54	3.68	3.78	3.85
1.0	0	.15	.64	1.14	1.46	1.93	2.40	2.83	3.15	3.39	3.57	3.69	3.79	3.86
2.5	0	.17	.65	1.16	1.51	1.95	2.47	2.88	3.17	3.40	3.58	3.71	3.80	3.87
5.0	0	.15	.63	1.13	1.46	1.90	2.40	2.85	3.15	3.40	3.57	3.69	3.78	3.85
7.5	0	.12	.58	1.07	1.45	1.89	2.40	2.83	3.14	3.39	3.56	3.68	3.76	3.82
10.0	0	.08	.05	.95	1.27	1.68	2.14	2.57	2.91	3.20	3.42	3.58	3.70	3.76

2 April 1966

JAVELIN - Voltage Mon - Temp. Cal.

Freq.	V In	V Out	Temp.
300 KHz	.2v p-p	3.25v	+40°C
400	"	3.30	"
500	"	3.40	"
600	"	3.40	"
700	"	3.40	"
800	"	3.45	"
900	"	3.45	"
1 MHz	"	3.45	"
2	"	3.42	"
3	"	3.42	"
4	"	3.42	"
5	"	3.42	"
6	"	3.40	"
7	"	3.30	"
8	"	3.30	"
9	"	3.20	"
10	"	3.00	"
11	"	2.70	"
12	"	3.30	"
1 MHz	"	3.20	-20°C
"	"	3.40	-10
"	"	3.40	0
"	"	3.50	+10
"	"	3.50	+20
"	"	3.50	+30
"	"	3.50	+40
"	"	3.50	+50
"	"	3.40	+60
"	"	3.40	+70

JAVELIN - Voltage Mon - Temp. Cal. (cont.)

Freq.	V In	V Out	Temp.
10 KHz	.2v p-p	2.[illegible]v	-20°C
"	"	2.9	-10°C
"	"	3.0	0
"	"	3.0	+10
"	"	3.1	+20
"	"	3.1	+30
"	"	3.1	+40
"	"	[illegible].0	+50
"	"	2.[illegible]	+60
"	"	2.[illegible]	+70

Electron Temperature Probe Antenna

Exposed surface:

Length - 25 5/16"

Diameter - .064 "

Material:

Gold plated phospher bronze

Unclassified

Security Classification

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13. ABSTRACT

Normal concentrations of electron density in the earth's ionosphere and changes in these concentrations associated with various disturbances, both natural and manmade, have been investigated by a series of eight rocket and satellite payloads. Instruments for measuring fine scale, long term deviations and short term, larger scale deviations in electron density and other related parameters have been included in each payload. This report details instrumentation and presents brief results of the experiments developed by Upper Air Research Laboratory, University of Utah, for each of the following programs:

Aerobee 150 (5.614)	-	E-region, gyro-interaction
Four Nike-Hydacs	-	Solar eclipse (12 November 1966)
OV2-3 Satellite	-	Electron density at synchronous orbit altitude
OV3-2 Satellite	-	F-region electron density (polar orbit)
Javelin (19.191)	-	F-region irregularities - pulse-phase delay experiment

Authors

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Satellite Instrumentation						
Electron Density Measurement Techniques						
Ionospheric Measurements						

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